

# Assessment of European Union Export Patterns for Plastic Waste before and after China's Waste Import Ban

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Unsustainable production and consumption of plastics is leading to the generation of large quantities of plastic waste, representing a challenge for waste management systems. The bulk of plastic waste is received by countries with less advanced technologies and infrastructure, and ends up in landfills, incinerated, or leaking to the environment. Before 2018, the European Union (EU) was highly dependent on exporting plastic waste to China, which accepted more than 50 % of its exports. However, China's ban on plastic waste imports, which came into force in 2018, has disrupted this established pattern profoundly. This study analyses the development of the EU's exports of plastic waste from 2000 to 2022, considering different types of plastics, polyethylene (PE), polystyrene (PS), polyvinyl chloride (PVC), and others. The results show that, after China's waste import ban, total exports of plastic waste fell by around 56 %, with Southeast Asia (44 %) and Turkey (31 %) emerging as new destinations for plastic waste exports. The findings of the study provide insights into understanding the dynamics of the EU's plastic waste export amidst an evolving regulatory landscape and improvements of waste managements.

## 1. Introduction

Plastics are ubiquitous materials that permeate various facets of daily life and are used in different sectors, particularly in the packaging sector (39 %), building and construction (23 %) and automotive (8 %) (Plastic Europe, 2023). It is present in a wide range of products, due to the ease of processing, cost-effectiveness and other desirable properties of plastics, displacing materials such as paper, wood, metal, glass and ceramics (Meng et al., 2024). In the last 50 y, global plastic production has increased ninefold, from 44 Mt/y to 400.3 Mt/y, with China (32 %), the rest of Asia (19 %), and Northern America (17 %) currently being the most important production locations (Plastic Europe, 2023).

Simultaneously with the increase in plastic production, the generation of plastic waste has become a significant environmental problem, with considerable amounts of plastic waste ending up in the marine environment. For instance, in 2019 in the European Union (EU), 2.11 Mt (13 %) of plastic waste was lost, of which 39 % was lost during the use phase, 17 % from mishandling and 12 % from incineration processes (Amadei et al., 2023). In line with the principles of the circular economy, it is essential to prioritise waste management and processing of plastic waste according to (zero-) waste principles and targets. Even with the most advanced waste management strategies, some of the hard-to-process plastic waste may still end up in countries with less advanced technologies and infrastructure (Liu et al., 2022).

Following China's ban on plastic waste imports, the EU has taken steps to regulate the production and use of plastics for single use. In 2018, the EU launched a comprehensive strategy for plastics, to protect the environment, reduce marine litter, greenhouse gas (GHG) emissions and the dependency on imported fossil fuels (European Commission, 2018). This strategy includes several key components, focusing on recyclability of packaging, improvements in the collection and sorting of plastic waste, reductions of microplastics use in products, and the promotion of bio-based, biodegradable and compostable plastics. In 2021, the EU introduced a ban on single-use plastics such as cotton buds, cutlery, straws and plates (European Commission, 2021),

while encouraging manufacturers to develop products following eco-design principles. In 2023, the European Parliament and the Council reached a political agreement to address the issue of plastic waste shipments from the EU to less developed countries. This agreement assigns greater responsibility to the EU for its waste, and prohibits any exports of plastic waste from the EU to non-OECD countries (European Commission, 2023).

Plastic waste and its trade patterns have attracted significant attention. Research studies have addressed various aspects of this topic, such as the study of plastic waste trends before and after China's ban, globally (Wang et al., 2020) and in the US (Bourtsalas et al., 2023), the trends detailing the exports of global waste streams per type of plastic before and after the ban (Liu et al., 2022), and a comprehensive study of plastic waste trade patterns in Asia (Liang et al., 2021). Additionally, studies examine EU plastic waste circularity (Hsu et al., 2021), estimates on plastic waste redistribution until 2030 (Brooks et al., 2018) and mismanagement of exported plastic waste (Cook and Velis, 2022).

This study assesses plastic waste export patterns from the EU from the year 2000, and analyses the final export destinations for four different types of polymers: polyethylene (PE), polystyrene (PS), polyvinyl chloride (PVC) and other plastics. It is also important to note that export flows between EU countries are omitted from the study. Special focus is placed on recent changes in the EU's export patterns caused by China's waste import ban, as China was the country which accepted most of plastic waste before the year 2018.

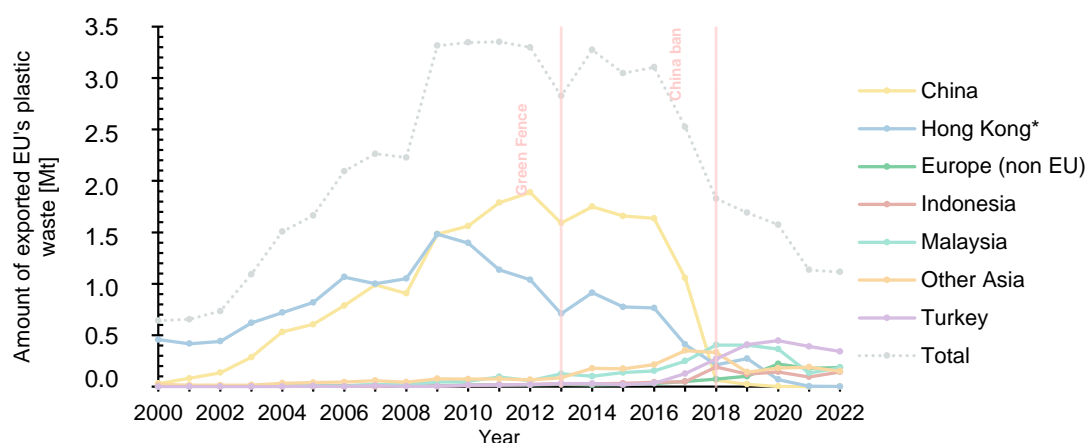
## 2. Export patterns of the European Union's Plastic Waste

This study assesses the export patterns of the EU's plastic waste from the year 2000 to the most recent year, based on available data (2022). Firstly, an overview is given of the export patterns of plastic waste. The analysis then focuses on the different types of plastic waste (PE, PS, PVC, and others) in terms of their amounts and final destinations of the EU's export. In addition, the impact of China's ban is analysed, to determine the changes in the EU's export strategies.

All the data on plastic waste streams were taken from the UN Comtrade Database (United Nations, 2022), which provides comprehensive international trade data regarding import and export flows of various commodities. From the database, the considered trade data classification was based on the Standard International Trade Classification (SITC), which allows coding for different international trade commodities. From the UN Comtrade database, annual values were obtained for the SITC Commodity Codes 5791 – Waste, pairings and scrap of polymers of ethylene (considered as PE), 5792 - Waste, pairings and scrap of polymers of styrene (considered as PS), 5793 - Waste, pairings and scrap of polymers of vinyl chloride (considered as PVC), and 5799 - Waste, pairings and scrap of other plastics (considered as Other plastics) (United Nations, 2022).

The dataset was used to aggregate the data on exports of plastic waste by country within a given year. In addition, the total quantities of plastic waste exported and the representative shares of these exports per country were calculated on an annual basis. To identify the main patterns of EU plastic waste export, the country data were aggregated into different continents (e.g. North America, Africa) or regions (e.g. Other Asia, Europe – non-EU).

Figure 1 shows annual global exports of plastic waste from the EU for the considered period from 2000 to 2022.



\* Hong Kong is a special administrative region (SAR) of China, and is managed separately.

Figure 1: EU's plastic waste export amounts from 2000 to 2022

As shown in Figure 1, the annual global exports of plastic waste have increased significantly over the first decade in the 21<sup>st</sup> century due to rising plastic consumption, from 0.64 Mt in 2000, to 3.35 Mt in 2010 (an increase of 522 %, compared to plastic consumption in 2000), followed by a significant decline to 1.12 Mt in 2022 (a decrease of 66 %, compared to the plastic consumption in 2010). This downward trend does not appear to be in line with the increase in the annual production of plastic waste. This underlines the impact of additional factors, including the need for implementation of stricter plastic waste management regulations leading to the detour of plastic waste from the EU to other countries, and the need for the development of an infrastructure for the treatment of plastic waste within the EU. This downward trend could also have occurred due to possible time lags, or illegal trade facilitated by smuggling operations (Li et al., 2021).

The initial decline in the EU's exports of plastic waste became apparent in 2013, coinciding with the implementation of China's "Green Fence" campaign, which resulted in a temporary embargo on waste imports (Brooks et al., 2018). Due to China's "Green Fence" policy being regarded as transient, EU countries initially stockpiled waste, while, later, they either treated waste domestically, or exported it to other countries through legal channels, or illegally. For example, in early 2018, around 2,600 t of waste composed mainly of non-segregated plastics from households and supermarkets, was transported illegally from the UK to Poland, declared falsely as green-listed plastic. In Poland, this waste was then disposed of illegally and burned in fires. Only in Poland at the beginning of 2018, a total of 80 different waste fires were documented (INTERPOL, 2020). In the first months of 2020, Malaysia, for example, returned 150 containers with a total volume of 3,737 t of illegally shipped plastic waste to 13 countries, including France and the United Kingdom (UK) (INTERPOL, 2020). In addition, INTERPOL has discovered various cases of illegal practices regarding plastic waste exports. After the Green Fence initiative in 2013, the level of trade in plastic waste did not return to pre-campaign levels. Further, it is seen that, from 2016, there was a notable shift in export destinations for plastic waste from the EU, with other Asian countries, such as Malaysia, India and Turkey, gradually displacing China and Hong Kong. However, after China imposed a ban on plastic waste imports in 2018, the EU's trade in plastic waste fell to 1.83 Mt (a 41 % decrease in 2 y). This downward trend continued until 2022, and, at the same time, other Asian countries followed China with not accepting plastic waste, by introducing their own Regulations on the import of plastic waste.

It is noteworthy that, in some cases, plastic waste underwent recycling processes to produce new products such as composites, quick-drying paints, waterproof coatings and others (Straková et al., 2022), or were incorporated into bitumen for road construction (Asare et al., 2019), while, in other cases, plastic waste was either incinerated or disposed of inadequately in open dumps, landfills (Sun et al., 2022), or leaked into oceans (Hossain et al., 2022). Figure 2 presents the amounts and shares of plastic waste by end-of-life fates of plastics in 2019 at the global level.

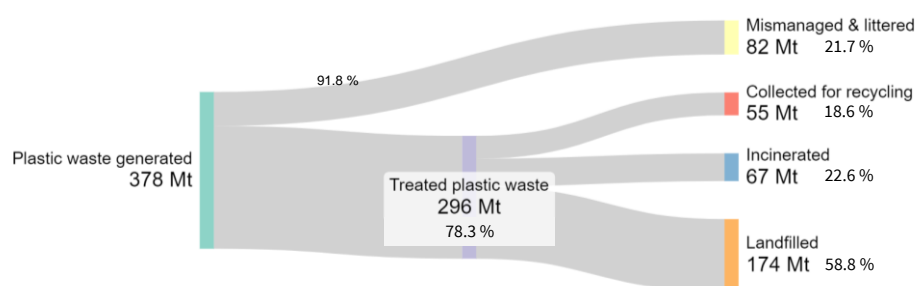


Figure 2: Plastic waste treatments by waste management categories in 2019 (OECD, 2022)

Figures 3 and 4 show the main destinations for the EU's exports of the four types of plastic waste, PE, PS, PVC and others before (Figure 2) and after China's ban (Figure 3). Between the years 2000 and 2015 (as shown in Figure 3), the main destinations for the EU's exports, regardless of the type of polymer, were China and Hong Kong. In addition, up to 6 % of PE waste was shipped to India, up to 7 % of PVC waste to Pakistan, and up to 9 % of other plastic waste to the United States (USA). China was also the main importer of plastic waste for the USA and Japan (Liu et al., 2022). Following China's ban (Figure 4), the EU began to diversify the destinations for plastic waste exports.

PE was the most widely used type of plastic. Before China's ban PE was routed mostly to Asia (96 %), with over 80 % of this waste reaching China and Hong Kong in 2015 (Huang et al., 2020). However, in the first few years after China's ban, the distribution of PE waste between the individual export destinations varied greatly. PE waste was, in the first year after the restrictions (in 2018), exported mainly to Malaysia (21 %), Indonesia (18 %), Turkey (16 %), India (12 %) and Vietnam (12 %). In 2021 and 2022, the countries' shares of PE's imports

changed, with Turkey becoming the main recipient (39 %), followed by Malaysia (18 %), Indonesia (15 %) and Vietnam (10 %). Despite Turkey introduced new regulatory measures in 2021, as part of its national legislation that restrict the import of plastic waste significantly (Gündoğdu and Walker, 2021), the impact of these Regulations was not apparent until 2022.

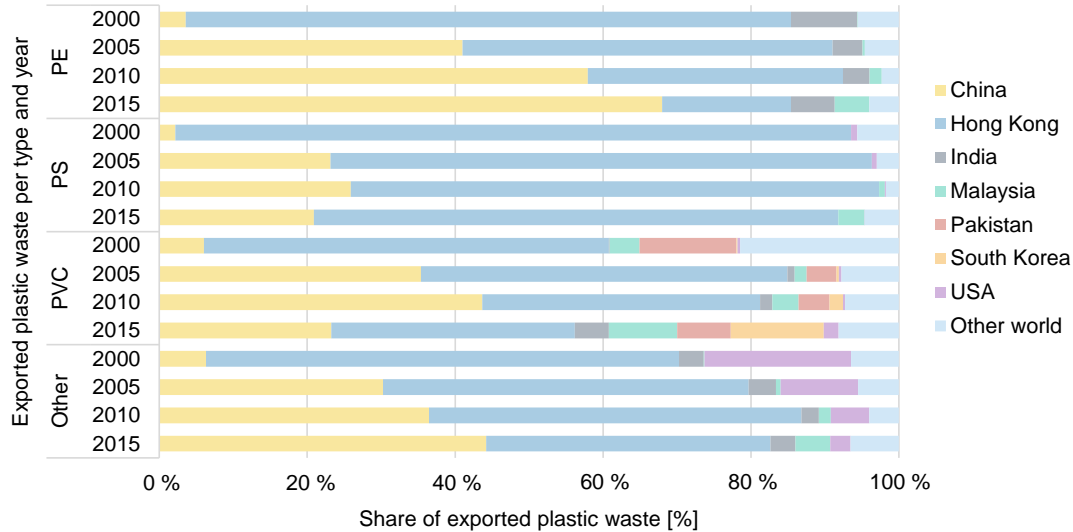


Figure 3: EU plastic waste export patterns before China's ban (2000 - 2015)

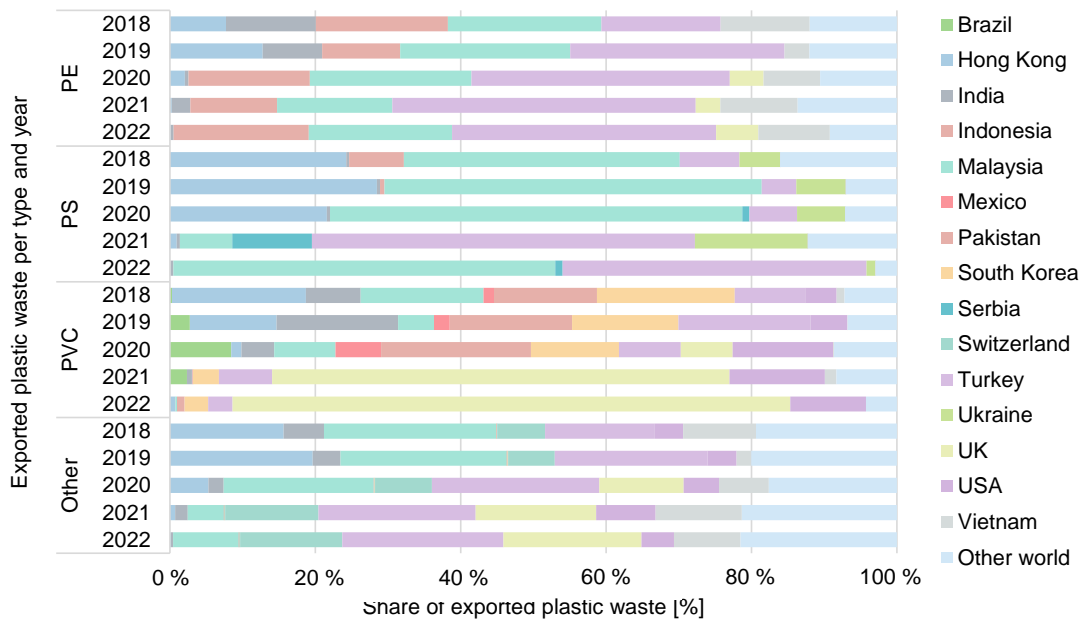


Figure 4: EU plastic waste export patterns after China's ban (2018 - 2022)

PS waste was, in 2018, shipped mainly to Malaysia (37 %), Hong Kong (24 %), countries in the "Other world" category (16 %), Turkey (8 %) and Ukraine (6 %). Notably, in the first 3 y after China's ban (until 2021), a significant amount of waste continued to be shipped to Hong Kong. In 2022, the main destinations for PS waste were Malaysia (53 %) and Turkey (42 %).

PVC waste export from the EU was, in 2018, distributed between South Korea (18 %), Hong Kong (18 %), Malaysia (16 %), Pakistan (14 %) and various other countries. Export destinations changed in the following years, with the majority of PVC waste exported from the EU in 2021 and 2022 to the UK (70 %) and the USA (12 %).

Other waste was, in 2018, shipped with a considerable proportion to Hong Kong (15 %), Malaysia (23 %) and Turkey (14 %). In the years until 2022, the export locations of other plastic waste changed greatly. In 2022, other plastic waste went to 6 countries, Turkey (22 %), countries categorised as "Other world" (21 %), the UK (19 %), Switzerland (14 %), Malaysia (9 %) and Vietnam (9 %).

Figure 5 finally illustrates the EU's plastic waste export flows in 2022. It can be seen that most of the PVC (83 %) and Other plastic waste (59 %) is exported to European (non-EU) countries, with these countries also receiving almost half of all PE (49 %) and PS waste (45 %). East Asia and the Pacific region are the second largest export destinations, accepting about half of PE and PS waste (50 % and 54 %), while lower amounts of Other plastic waste (25 %) and PVC (5 %). North Africa and the Middle East have emerged as destinations for other plastics (9 %), while North America received PVC (11 %) and other plastics (5 %). It can also be seen that there were no exports of plastic waste in 2022 to Latin America, the Caribbean or Sub-Saharan Africa.

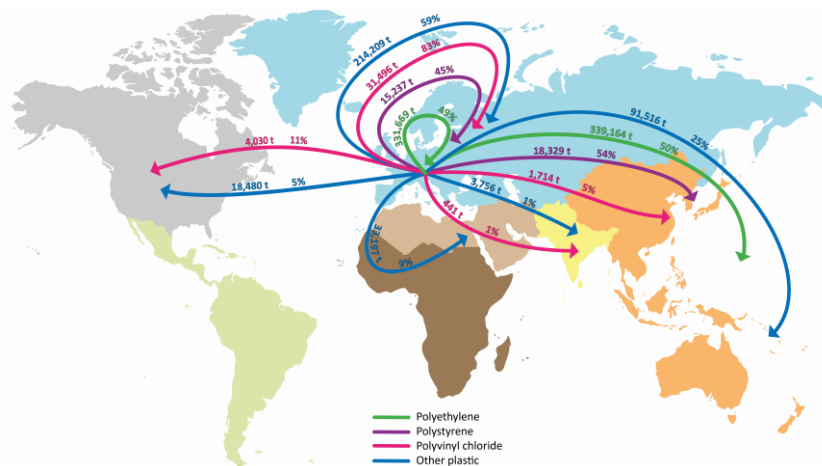


Figure 5: EU plastic waste flows per polymer type in 2022

### 3. Conclusions

This study provides an overview of the fate of plastic waste exported from the EU in the years 2000 to 2022. The volume of exported plastic waste has decreased in recent decades, which is in contrast with the growth in plastic production. The shift occurred mainly after China's plastic waste import ban in 2018 and closing other international plastic waste trade routes. Such decreased export amounts point to two possible consequences: i) The EU has improved its waste management and resource efficiencies, leading to increased domestic processing of plastic waste, and ii) An increase of illegal shipments of waste, leading to incineration, illegal waste burning, landfill, and/or dumping. Just before 2018, China and Hong Kong became the main importers of plastic waste from the EU, accepting 60 % of PE, 57 % of PS, 15 % of PVC and 57 % of Other plastic waste (2017 data). However, the ban imposed by China has disrupted the dynamics of the EU's waste trade significantly. Turkey has since become the leading destination for the EU's plastic waste, followed by Malaysia and other European (non-EU) countries, which is different from the US, where plastic waste has been shifted mainly to South Asian countries.

A recognisable pattern was found, that EU exporters divert their plastic waste to less developed countries where less strict Regulations are imposed on waste management. Asian countries remain among the top five destinations for the export of plastic waste from the EU, despite the implementation of import restrictions, bans, and compliance with multilateral environmental agreements such as the Basel Convention. As the EU has recently adopted new Regulations for the shipment of plastic waste beyond its borders, there is a possibility that export patterns will shift in the next years. It is foreseen that the volumes destined to Turkey will increase, as Turkey is one of the members of the OECD, and the restrictions on EU's plastic waste exports are not imposed for the OECD member states.

It is important to acknowledge that the limitations of the study are related to possible inaccuracies in the data, which may be influenced by factors such as human errors, inconsistencies in data collection, incomplete data, biased reporting and other factors. The exclusive use of a single database could lead to variability, as different databases may provide different results. This discrepancy should be considered in future research studies. In addition, future research could focus on comparative environmental impact assessment of plastic waste trade, and on cost-benefit analysis of various strategies for the management and transport of plastic waste.

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## References

- Amadei A.M., Rigamonti L., Sala S., 2023, Exploring the EU plastic value chain: A material flow analysis. *Resources, Conservation and Recycling*, 197, 107105.
- Asare P.N.A., Kuranchie F.A., Ofosu E.A., 2019, Evaluation of incorporating plastic wastes into asphalt materials for road construction in Ghana. *Cogent Environmental Science*, 5, 1576373.
- Bourtsalas A.C. (Thanos), Yepes I.M., Tian Y., 2023, U.S. plastic waste exports: A state-by-state analysis pre- and post-China import ban. *Journal of Environmental Management*, 344, 118604.
- Brooks A.L., Wang S., Jambeck J.R., 2018, The Chinese import ban and its impact on global plastic waste trade. *Science Advances*, 4(6), eaat0131.
- Cook E., Velis C., 2022, Plastic waste exports and recycling: Myths, misunderstandings, and inconvenient truths. *Waste Management and Research*, 40(10), 1459-1461.
- European Commission, 2023, Political agreement on stronger control of exports of waste, <ec.europa.eu/commission/presscorner/detail/en/ip\_23\_5818>, accessed 02.08.2024.
- European Commission, Directorate-General for Environment, 2021, Turning the tide on single-use plastics. Publications Office of the European Union, <op.europa.eu/en/publication-detail/-/publication/fbc6134e-367f-11ea-ba6e-01aa75ed71a1/language-en>, accessed 02.08.2024.
- European Commission, 2018, Plastic Waste: a European strategy to protect the planet, defend our citizens and empower our industries, <ec.europa.eu/commission/presscorner/detail/en/IP\_18\_5>, accessed 01.04.2024.
- Gündoğdu S., Walker T.R., 2021, Why Turkey should not import plastic waste pollution from developed countries? *Marine Pollution Bulletin*, 171, 112772.
- Hossain R., Islam M.T., Shanker R., Khan D., Locock K.E.S., Ghose A., Schandl H., Dhodapkar R., Sahajwalla V., 2022, Plastic Waste Management in India: Challenges, Opportunities, and Roadmap for Circular Economy. *Sustainability*, 14(8), 4425.
- Hsu W.T., Domenech T., McDowall W., 2021, How circular are plastics in the EU?: MFA of plastics in the EU and pathways to circularity. *Cleaner Environmental Systems*, 2, 100004.
- Huang Q., Chen G., Wang Y., Chen S., Xu L., Wang R., 2020, Modelling the global impact of China's ban on plastic waste imports. *Resources, Conservation and Recycling*, 154, 104607.
- INTERPOL, 2020, INTERPOL strategic analysis report: Emerging criminal trends in the global plastic waste market since January 2018, <interpol.int/en/content/download/15587/file/INTERPOL%20Report%20\_criminal%20trends-plastic%20waste.pdf>, accessed 01.04.2024.
- Li C., Wang L., Zhao J., Deng L., Yu S., Shi Z., Wang Z., 2021, The collapse of global plastic waste trade: Structural change, cascading failure process and potential solutions. *Journal of Cleaner Production*, 314, 127935.
- Liang Y., Tan Q., Song Q., Li J., 2021, An analysis of the plastic waste trade and management in Asia. *Waste Management*, 119, 242–253.
- Liu X., Lei T., Boré A., Lou Z., Abdouraman B., Ma W., 2022, Evolution of global plastic waste trade flows from 2000 to 2020 and its predicted trade sinks in 2030. *Journal of Cleaner Production*, 376, 134373.
- Meng F., Brandão M., Cullen J.M., 2024, Replacing plastics with alternatives is worse for greenhouse gas emissions in most cases. *Environmental Science and Technology*, 58(6), 2716–2727.
- OECD, 2022, Global Plastics Outlook: Economic Drivers, Environmental Impacts and Policy Options. OECD Publishing, <oeed-ilibrary.org/environment/global-plastics-outlook\_de747aef-en>, accessed 13.07.2024.
- Plastic Europe, 2023, Plastics – the fast Facts 2023, <plasticseurope.org/knowledge-hub/plastics-the-fast-facts-2023/>, accessed 09.03.2024.
- Straková J., Grechko V., Brosché S., Karlsson T., Buonsante V., 2022, Plastic waste management and burden in China. International Pollutants Elimination Network (IPEN), <ipen.org/sites/default/files/documents/ipen-china-2021-epa\_v1\_2.pdf>, accessed 02.08.2024.
- Sun Y., Liu S., Wang P., Jian X., Liao X., Chen W.Q., 2022, China's roadmap to plastic waste management and associated economic costs. *Journal of Environmental Management*, 309, 114686.
- United Nations, 2022, UN Comtrade. UN Comtrade Database. <comtradeplus.un.org/>, accessed 03.03.2024.
- Wang C., Zhao L., Lim M.K., Chen W.Q., Sutherland J.W., 2020, Structure of the global plastic waste trade network and the impact of China's import Ban. *Resources, Conservation and Recycling*, 153, 104591.