Wasted Space:

An Investigation into Non-Functional Slack Filling with Implications for the Global Plastic Treaty and Beyond.

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Acknowledgements

Tangaroa Blue Foundation is an Australian not-for-profit organisation dedicated to the removal and prevention of marine debris. Founded in 2004, Tangaroa Blue coordinates the Australian Marine Debris Initiative (AMDI), a national program that empowers communities, businesses, and government bodies to clean-up and monitor marine environments.

The AMDI brings together citizen science data from over 3,100 partners and is the largest marine debris database in the southern hemisphere. Through its data-driven approach, Tangaroa Blue works to identify the origin of marine debris and develop solutions to prevent pollution at its source.

The **International Waste Platform (IWP)** is a not-for-profit organisation initiated in 2018 during the 6th International Marine Debris Conference in San Diego. By 2023, stakeholder networks from 35 countries had connected to collaborate on Ocean Action, Climate Action, addressing pollution from land-based, riverine and marine-based sources and advancing Circular Economy development. IWP provides international overview, expertise and launch joint initiatives; they support advancing solutions to mitigate the interlinked global waste, plastic pollution, and climate crises.

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Graphic design by Tangaroa Blue Foundation

Acronyms

UNEA - United Nations Environment Assembly
CGF - Consumer Goods Forum

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Image: Marine debris on Christmas Island (Tangaroa Blue Foundation)

Executive summary

Plastic pollution is a critical environmental crisis, with the United Nations Environment Programme projecting that plastic waste in aquatic ecosystems could triple by 2040 without proper interventions.[1] Beyond its environmental impacts, plastic production is a significant contributor to the climate crisis due to its dependence on fossil fuels.[2] At every stage of its life cycle - from extraction and refining to disposal - plastics generate greenhouse gas emissions, exacerbating global warming and threatening climate stability.[3] The packaging sector, responsible for 36% of all plastic produced, is the largest contributor to single-use plastic waste.[4] The packaging chosen for certain products is heavily influenced by marketing choices, which can establish a brand's identity and influence consumer experience. Non-functional slack filling (see Box 1 for definition[5]) exacerbates the plastic crisis, contributing to unnecessary plastic production and waste while potentially misleading consumers about product quantity.

Box 1: Definition of slack fill and non-functional slack fill

Following the guidelines of the United States of America Code of Federal States, this paper classifies slack fill as "the difference between the actual capacity of a container and the volume of product contained therein."

Non-functional slack fill is the empty space in a package that is filled to less than its capacity for reasons other than:

(1) Protection of the contents of the package;
(2) The requirements of the machines used for enclosing the contents in such package;
(3) Unavoidable product settling during shipping and handling;
(4) The need for the package to perform a specific function (e.g., where packaging plays a role in the preparation or consumption of a food), where such function is inherent to the nature of the food and is clearly communicated to consumers;
(5) The fact that the product consists of a food packaged in a reusable container where the container is part of the presentation of the food and has value which is both significant in proportion to the value of the product and independent of its function to hold the food, e.g., a gift product consisting of a food or foods combined with a container that is intended for further use after the food is consumed; or durable commemorative or promotional packages; or
(6) Inability to increase level of fill or to further reduce the size of the package (e.g., where some minimum package size is necessary to accommodate required food labeling (excluding any vignettes or other nonmandatory designs or label information), discourage pilfering, facilitate handling, or accommodate tamper-resistant devices).

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[1] United Nations Environment Programme (2021). From Pollution to Solution. A Global Assessment of Marine Litter and Plastic Pollution. https://www.unep.org/interactives/beat-plastic-pollution/
[2] Ford, H. V., Jones, N. H., Davies, A. J., Godley, B. J., Jambeck, J. R., Napper, I. E., Suckling, C. C., Williams, G.J., Woodall, L. C., & Koldewey, H. J. (2022). The fundamental links between climate change and marine plastic pollution. Science of The Total Environment, 806, 150392. https://doi.org/10.1016/j.scitotenv.2021.150392
[3] González, Daniela Durán , Radvany, R., & Azoulay, D. (2023). Reducing Plastic Production to Achieve Climate Goals: Key Considerations for the Plastics Treaty Negotiations . Center for International Environmental Law.
[4] Ibid.
[5] Food and Drugs. 21 Code of Federal Regulations §100.100. (1994) https://www.ecfr.gov/current/title-21/chapter-I/subchapter-B/part-100/subpart-F/section-100.100

This study aims to quantify the extent of non-functional slack filling in food and consumer packaging across multiple countries and assess its contribution to avoidable plastic use. By focusing on this easily addressable aspect of packaging design, the research seeks to identify opportunities for significant waste reduction, aligning with the goals of the international legally binding instrument on plastic pollution, including in the marine environment (henceforth the 'global plastic treaty') and supporting the transition towards a more sustainable, circular economy for plastics.

Using a citizen science approach, volunteers sampled products from fourteen countries to measure and document instances of non-functional slack filling in food and consumer goods packaging. Participants measured dimensions and volumes of the packaging and the Tangaroa Blue Foundation data team reviewed the data for quality assurance and calculated the percentage of non-functional space in various products. This methodology provides an initial perspective on this global issue and its potential impact on developing global binding instruments on plastic pollution for policy-makers, industry and civil society.

Limitations

The study acknowledges several limitations:

1. This data is exploratory in nature.
2. The sample size is relatively small and may not be fully representative of all product categories or regions.
3. Further research is needed to fully understand the scale and implications of non-functional slack fill across a wider range of products and regions.
    a. For some products, a portion of the slack fill identified may be functionally necessary (see Box 1). Where functional slack fill is necessary, there is still an opportunity to reduce excessive slack fill in many instances. For example, powders such as flour and rice can often be packaged more tightly with minimal slack fill, demonstrating that even for products where settling is a factor, more efficient packaging solutions are possible. This underscores the need to carefully assess which slack fill is genuinely functional and where reductions can be made without compromising product integrity.

Despite these limitations, the consistency of findings across multiple countries highlights the urgency of addressing this issue.

Image: Plastic pollution in a marine setting (Tangaroa Blue Foundation)

Key findings

Widespread non-functional slack filling

Non-functional slack filling was found in 89% of products examined, with over 50% of packaging deemed surplus, highlighting a pervasive issue across food and consumer goods categories.

Global nature of the issue

Examples of non-functional slack filling were found in all 14 countries sampled, demonstrating that this is a global issue and not limited to specific regions or markets.

Prevalence of soft plastics

The majority of packaging sampled was made or included components of soft plastics. This is significant because soft plastics are often more challenging to recycle and contribute substantially to plastic pollution.[7]

Large non-functional volume

On average, 70% of the packaging volume across all products is non-functional, meaning that only 30% of packaging is used to contain the actual product. This suggests a significant opportunity for reducing packaging waste.

Extreme cases in snack foods

Analysing the results by category, 90% of sampled snack food products had over 75% surplus packaging, with an average of 86% non-functional space. Non-functional slack filling was particularly prevalent in this category and this finding is especially significant when considering the broader scale of the snack food market.

In 2024, the global revenue for snack foods is projected to reach US$251.10 billion, with each person estimated to consume 5.0 kg of snack food annually.[6] By 2029, it is expected that 45.40 billion kilograms of snack food will be consumed.[3]

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[6] Statista. (n.d.). Snack Food - Worldwide | Statista Market Forecast. https://www.statista.com/outlook/cmo/food/confectionery-snacks/snack-food/worldwide

[7] Shittu, O., Arnautovic, K., Lockrey, S., Vince, J., Vogel, R., Bhattacharya, A., Stanes, E., Garofano, N., Retamal, M., & Harkness, M. (2024). Governance solutions for soft plastics in Australia: lessons from the discontinuation of REDcycle. Australasian Journal of Environmental Management, 1–27. https://doi.org/10.1080/14486563.2024.2367960

Recommendations: Plastic producers

1

Conduct regular packaging audits to identify and eliminate instances of non-functional slack filling.

2

Invest in innovative packaging design that minimises non-functional space while maintaining product protection.

3

Adopt flexible packaging systems that can adapt to different product volumes.

4

Collaborate with retailers and distributors to optimise packaging throughout the supply chain.

5

Follow the European Union's lead and implement the Digital Product Passport (DPP) globally.[8] The DPP includes essential details such as a unique product identifier, compliance documentation, and information on substances of concern. It will also provide user manuals, safety instructions, and guidance on product disposal.

We propose that it further educates consumers on packaging choices and how reduced slack fill contributes to sustainability. To ensure transparency and credibility, independent third-party verification of packaging information published by brand-owners in the digital system is essential, providing consumers with trustworthy data on product sustainability.

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[8]Publications Office of the EU. (2024, September 27). data.europa.eu. Data.Europa.Eu. https://data.europa.eu/en/news-events/news/eus-digital-product-passport-advancing-transparency-and-sustainability

Image: Quality check (Boonterm via AdobeStock)

Recommendations: Policy-makers

1. **Legislate national and international mandatory product design requirements to limit non-functional slack filling,** setting maximum allowable percentages for non-functional space in packaging.
2. **Develop and implement international standards** and definitions for functional and non-functional slack filling.
3. **Incentivise sustainable packaging design** through tax incentives or grants.
4. **Mandate transparency in packaging** by requiring clear indication of functional vs. non-functional space on product labels.
5. **Integrate slack fill reduction into broader plastic pollution strategies** and global plastics treaty negotiations.

Non-functional slack filling represents a significant contributor to global plastic waste, but with engagement from policy-makers, plastic producers and consumers, it can be addressed.

This study highlights the prevalence of excess, non-functional packaging across multiple countries and various product categories, with particularly large quantities of excess packaging in snack foods. Addressing this problem presents an opportunity to reduce unnecessary plastic production and waste without compromising product integrity or consumer experience.

The findings underscore the need for international standards, stricter international, national and local regulations, and industry innovation to tackle non-functional slack filling. By focusing on this aspect of packaging design, significant reductions in plastic waste and pollution could be achieved, contributing to the broader goals of the global plastic treaty and moving towards a more sustainable, circular economy for plastics.

While further research is needed to fully understand the scale and implications of non-functional slack fill, the consistency of findings across multiple countries highlights the urgency of taking action. Collaboration between policy-makers, industry leaders, and consumers will be crucial in implementing effective solutions to this widespread issue, ultimately contributing to global efforts to combat plastic pollution.

1. Introduction

Plastic pollution has emerged as one of the most pressing environmental crises of our time. According to the United Nations Environment Programme (UNEP), without proper interventions, the volume of plastic waste entering aquatic ecosystems could triple by 2040.[9]

The packaging sector is the largest contributor to single-use plastic waste globally, with 36% of all plastic produced being used for packaging.[10] Alarmingly, approximately 85% of all plastic packaging ends up in landfills or as unregulated waste.[11] Due to the linear nature of the current system (i.e., take-make-waste), after a very short first use, 95% of the aggregate value of plastic packaging - $80 billion to $120 billion USD per year - is lost to the economy.[12]

Within the realm of packaging, the concept of slack filling (Box 1) - the empty space left in a package - has gained attention as a potential area for reducing unnecessary production, use and waste of plastic. While some slack fill serves functional purposes, such as protecting contents during shipping or a result of the product settling during transport, there are many instances where this empty space serves no recognised function. Regulations on "non-functional slack filling" are an opportunity to reduce plastic production and waste without compromising product integrity and consumer experience.

Non-functional slack filling in the cosmetic and food industries has been recognised for misleading consumers leading to several known class action cases. For instance, in 2017, a class action lawsuit was filed against Wise Foods Inc. for allegedly filling their potato chip bags with up to 58-75% air, far beyond what was necessary to protect the product, although the case was later dismissed.[13] Similarly, in 2018, Nestlé faced a class action lawsuit over slack fill in their Raisinets chocolates boxes.[14] Several instances of 'shrinkflation' have also been recognised by consumers, where brands avoid raising prices by downsizing packaging or reducing the amount of product within it.[15] When the amount of product is reduced but the packaging size is not changed, it can increase non-functional slack fill, leading to more packaging waste and potential consumer deception. These cases highlight the growing consumer awareness and dissatisfaction with non-functional slack filling. Industry reform is necessary to address both environmental and consumer concerns.

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[9] Ibid.
[10] Ibid.
[11] Ellen MacArthur Foundation, "New Plastics Economy 2021 Recycling Rate Survey results summary". Available at https://emf.thirdlight.com/link/glw5k7awhdym-qfl3fa/@/. See table 1, pp. 5–6.
[12] Ibid.
[13] Aliano v. Wise Foods, Inc., No. 1:17-cv-02402 (S.D.N.Y. filed Apr. 3, 2017. Accessed via Public Access to Court Electronic Records website: https://pacer.uscourts.gov/
[14] Thomas v. Nestlé USA, Inc., No. 5:18-cv-03702 (N.D. Cal. filed June 20, 2018. Accessed via Public Access to Court Electronic Records website: https://pacer.uscourts.gov/ Case file here: http://online.wsj.com/public/resources/documents/2017_0103_raisenets_suit.pdf
[15] Pierce, L. M. (2024, February 22). President Biden blasts packaging shrinkflation. Packaging Digest. https://www.packagingdigest.com/packaging-design/president-biden-blasts-packaging-shrinkflation

To investigate the prevalence of non-functional slack filling globally, researchers from Tangaroa Blue Foundation and the International Waste Platform designed a citizen science project, for which the preliminary results are presented in this white paper. Citizen scientists sampled product packaging from fourteen countries, measured the volume of products against their packaging size, and calculated the percentage of non-functional space.

The results from this pilot study demonstrate that non-functional slack filling is prevalent across various product categories in all 14 countries, contributing substantially to avoidable plastic use. Importantly, the majority of the packaging analysed was made of soft plastics, which presents a particular challenge for consumers. Currently, individuals can either try to avoid soft plastics altogether or, in some countries, attempt to recycle them. The choice of product often becomes a sticking point for environmentally conscious consumers who find themselves limited by available packaging options.

Recognising the urgent need for international collaboration and intervention to address plastic pollution, United Nations Environment Assembly Resolution 14 (UNEA-5.2/Res 14) was adopted in March 2022, with Parties deciding “to develop an international legally binding instrument on plastic pollution, including in the marine environment” (henceforth the ‘global plastic treaty’).[2] The global plastic treaty is required to take a “comprehensive approach that addresses the full life cycle of plastic”. While the scope of the treaty is still under negotiation, many are arguing that for an ambitious treaty, the life cycle should extend from extraction of fossil fuels to the generation and treatment of waste.

Addressing non-functional slack fill in packaging presents a "low-hanging fruit" opportunity to curb plastic production, use and waste. By focusing on this easily addressable aspect of packaging design, significant reductions in plastic waste could be achieved, contributing to the broader goals of the global plastic treaty and moving towards a more sustainable, circular economy for plastics.

Image: Jilgi Beach (Tangaroa Blue Foundation)

2. Key findings

Widespread non-functional slack filling: In 89% of all products examined, over half of the packaging (50%) was surplus. This indicates that non-functional slack filling is a pervasive issue across various food and consumer goods categories.

Global nature of the issue: Examples of non-functional slack filling were found in all 14 countries sampled, demonstrating that this is a global issue and not limited to specific regions or markets.

Prevalence of soft plastics: The majority of packaging sampled was made or included components of soft plastics. This is significant because soft plastics are often more challenging to recycle and contribute substantially to plastic pollution.

Large non-functional volume: On average, 70% of the packaging volume across all products is not functional, meaning that only 30% of packaging is used to contain the actual product. This suggests a significant opportunity for reducing packaging waste.

Extreme cases in snack foods: Analysing the results by category, 90% of sampled snack food products had over 75% surplus packaging, with an average of 86% non-functional space. Non-functional slack filling was particularly prevalent in this category. This is crucial to address as it is expected that by 2029, 45.4 billion kilograms of snack food will be consumed.

3. Global context

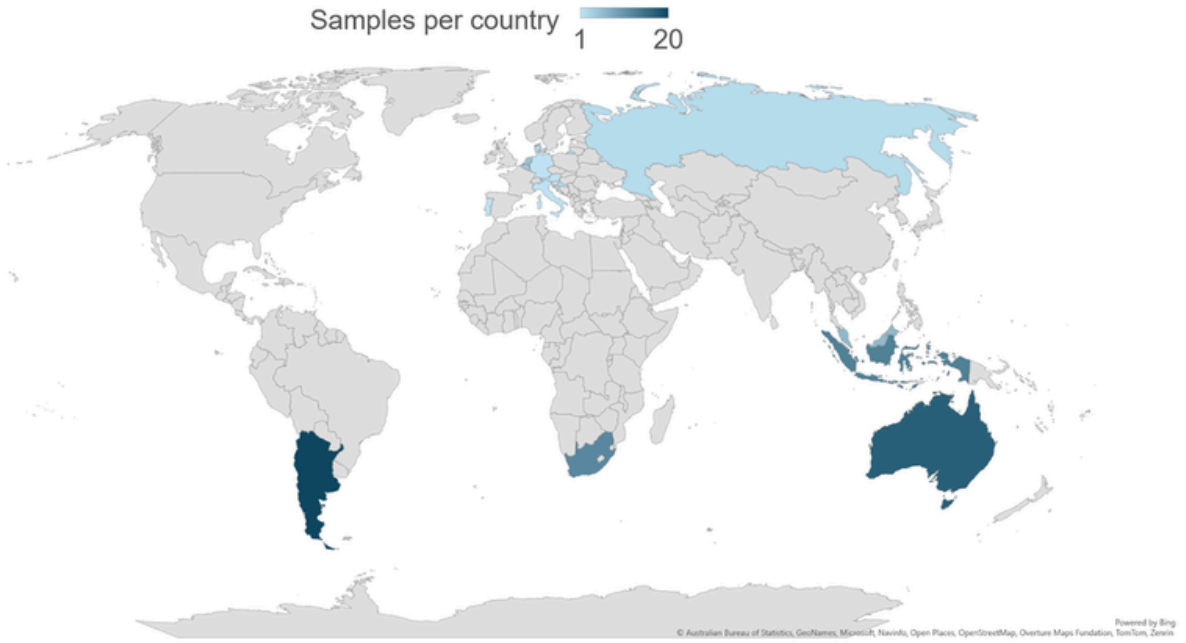
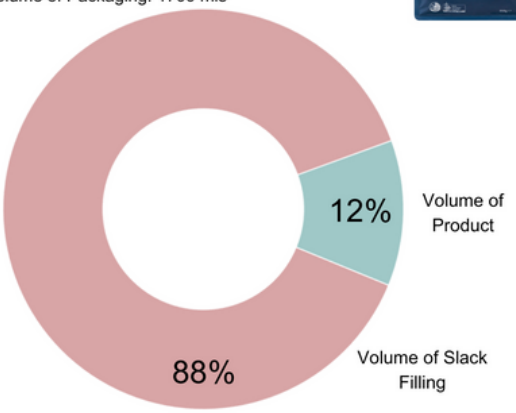


Figure 1: Global map showing the number of samples audited from each country.

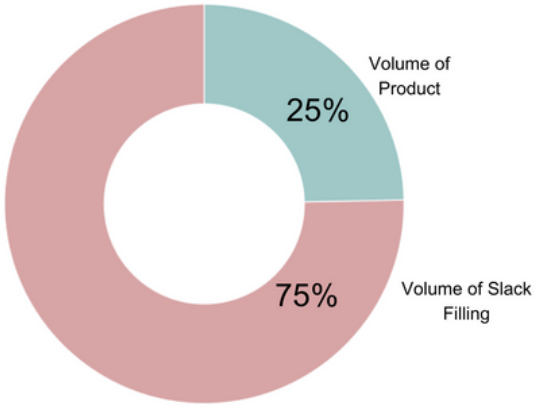
Brand/Product: Organic Coconut Flakes

Country: Australia
Product Type: Nuts and Cereals
Material: Soft Plastic Packaging
Volume of Product: 200 mls
Volume of Packaging: 1700 mls



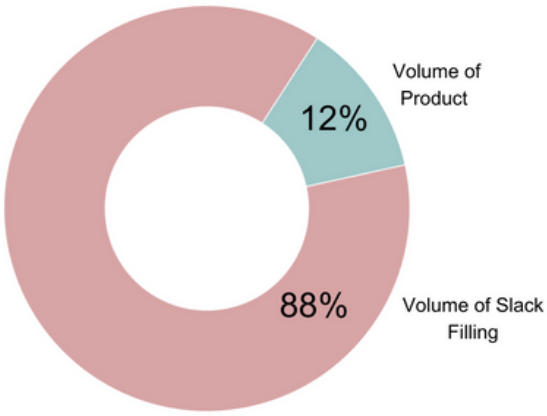
Brand/Product: Tide Pods

Country: Australia
Product Type: Cleaning Product
Material: Soft Plastic Packaging
Volume of Product: 395 mls
Volume of Packaging: 1600 mls



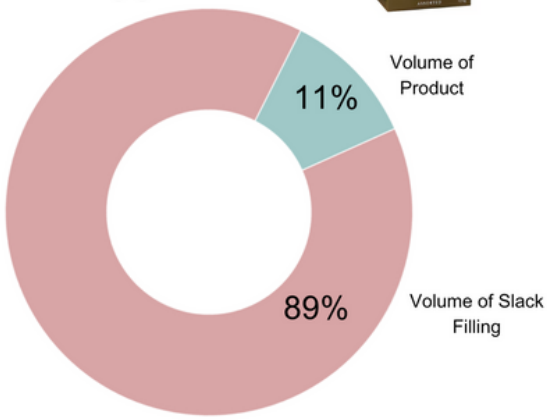
Brand/Product: Gravox Diane Sauce

Country: Australia
Product Type: Condiments
Material: Soft Plastic Packaging
Volume of Product: 31 mls
Volume of Packaging: 250 mls



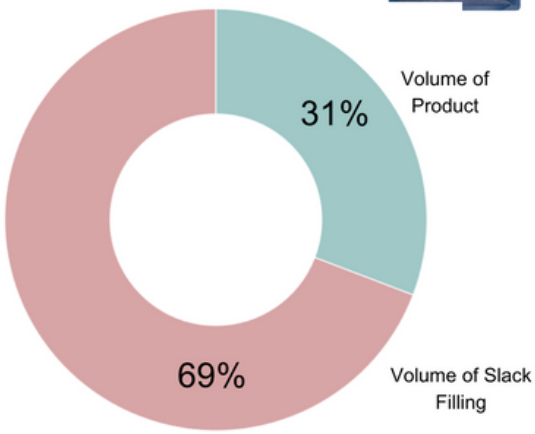
Brand/Product: Lindt Assorted

Country: Australia
Product Type: Confectionary
Material: Soft Plastic Packaging
Volume of Product: 130 mls
Volume of Packaging: 1200 mls



Brand/Product: Maca Powder

Country: Australia
Product Type: Beverage
Material: Soft Plastic Packaging
Volume of Product: 154 mls
Volume of Packaging: 500 mls



Brand/Product: Vita Gummies

Country: Australia
Product Type: Supplements and Vitamins
Material: Hard Plastic Packaging
Volume of Product: 197 mls
Volume of Packaging: 500 mls

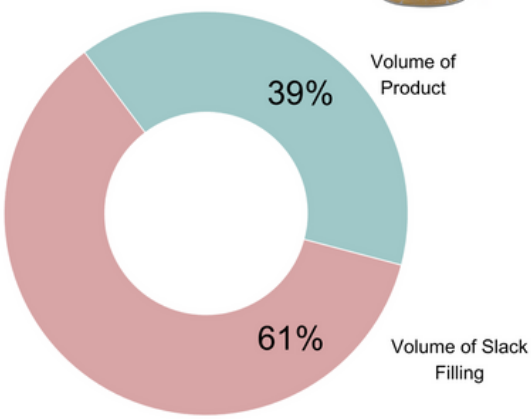


Figure 2: Key examples of non-functional slack filling.

4. Impacts

Excess packaging is an issue with environmental, social and economic implications. While the impacts are widespread, we have investigated the main impacts here and summarised these in Table 1, with more detail available throughout section 4. Please note that all the solutions presented below are recommended to be implemented in conjunction with methods to reduce the production, use and waste of plastic.

Table 1: Summary of the impacts of non-functional slack fill to the environment, economy and society and the proposed solutions and benefits.

Problem	Solution	Long-term benefits
The packaging sector is the largest contributor to single-use plastic waste globally, with 36% of all plastic produced being used for packaging.[16] Inadequate safe disposal has led to approximately 85% of all plastic packaging ending up in landfills or as unregulated waste.[17]	More efficient packaging design to reduce plastic used in packaging.	Address the significant contribution of macroplastics to microplastic pollution in the marine environment.[18]
Contributions of the plastics industry to greenhouse gases.	Reduce the volume and quantity of plastic needed to contain products.	Support efforts to minimise emissions and keep global temperature rise below 1.5°C, in line with the Paris Agreement.
Due to the linear nature of the current system (i.e., take-make-waste), there are significant losses to the economy at the end of the product's life cycle. For instance, after a very short first use, 95% of the aggregate value of plastic packaging is lost to the economy, equating to a loss of $80 billion to $120 billion USD per year.[19]	Products use less packaging material and with smaller, more efficient packaging, more items can be transported in fewer shipments.	Brand-owners can lower material costs, potentially saving millions in production expenses. Cheaper transportation costs including fuel consumption and shipping fees.
Non-functional slack fill can mislead consumers, making products appear larger than they are, which may lead to consumer dissatisfaction[20] and possible fines.[21]	Reducing the non-functional space in products could be an opportunity for brands to be more transparent with their packaging.	Potentially enhancing brand trust and loyalty. As consumer preferences shift toward sustainability, companies that take proactive steps to reduce waste may also find themselves in a stronger competitive position, tapping into new markets and attracting environmentally conscious customers.

[16]United Nations Environment Programme (2021). *From Pollution to Solution. A Global Assessment of Marine Litter and Plastic Pollution.* https://www.unep.org/interactives/beat-plastic-pollution/

[17]Ellen MacArthur Foundation, "New Plastics Economy 2021 Recycling Rate Survey results summary". Available at https://emf.thirdlight.com/link/glw5k7awhdym-qfl3fa/@/. See table 1, pp. 5–6.

[18]Thompson, R. C., Courtene-Jones, W., Boucher, J., Pahl, S., Raubenheimer, K., & Koelmans, A. A. (2024). Twenty years of microplastics pollution research—what have we learned? Science. https://doi.org/10.1126/science.adl2746

[19] Ellen MacArthur Foundation, "New Plastics Economy 2021 Recycling Rate Survey results summary". Available at https://emf.thirdlight.com/link/glw5k7awhdym-qfl3fa/@/. See table 1, pp. 5–6.

[20] Wilkins, S., Beckenuyte, C., & Butt, M. M. (2016). Consumers' behavioural intentions after experiencing deception or cognitive dissonance caused by deceptive packaging, package downsizing or slack filling. European Journal of Marketing, 50(1/2), 213–235. https://doi.org/10.1108/ejm-01-2014-0036

[21] Turner, A. (2022, September 28). Shrinkflation: Product Downsizing Risks and Opportunities to Consider. NTT DATA. https://us.nttdata.com/en/blog/2022/september/shrinkflation-product-downsizing-risks-and-opportunities-to-consider

4.1 Environmental impacts

The packaging sector is the largest contributor to single-use plastic waste globally, with 36% of all plastic produced being used for packaging.[22] Inadequate safe disposal has led to approximately 85% of all plastic packaging ending up in landfills or as unregulated waste.[23]

Plastic packaging continues to dominate many environmental surveys of debris in marine environments. For example, of the 1.5 million tonnes of plastic consumed annually in Australia, ~37%, or 24 kg of plastic waste per person, is single-use packaging.[24] The contamination and exposure of marine habitats and species to plastics has been linked to a suite of impacts, including the deterioration of species and ecosystem health[25] and impacts to economic sectors and coastal livelihoods.[26]

More efficient packaging design can help address the significant contribution of macroplastics to microplastic pollution in the marine environment, which Thompson et al. (2024) identify as the largest source of microplastics.[27] Macroplastics, including packaging items, are the main source of microplastics as they break up over time due to UV radiation, wave action, and other environmental factors. By reducing non-functional slack fill and designing more efficient packaging, we can significantly lower the amount of plastic that enters the environment, minimising the risk of these larger plastic items fragmenting into harmful microplastics.

The rapid growth of the plastics industry is also undermining efforts to reduce greenhouse gas emissions and achieve global temperature rise below 1.5°C, in line with the Paris Agreement. Greenhouse gases are produced at every stage of the plastics life cycle, from extraction of fossil fuels to the illegal dumping or pollution.[28] It's estimated that if it continues to grow, by 2050 plastic production will use up 10-13% of the remaining carbon budget.[29]

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[22]United Nations Environment Programme (2021). From Pollution to Solution. A Global Assessment of Marine Litter and Plastic Pollution. https://www.unep.org/interactives/beat-plastic-pollution/
[23]Ellen MacArthur Foundation, "New Plastics Economy 2021 Recycling Rate Survey results summary". Available at https://emf.thirdlight.com/link/glw5k7awhdym-qfl3fa/@/. See table 1, pp. 5–6.
[24]Environment and Communications References Committee (2016). Toxic Tide: The Threat of Marine Plastic Pollution in Australia. (ISBN: 978-1-76010-400-9). Canberra, Australia.
[25]R.C. Thompson, C.J. Moore, F.S. Vom Saal, S.H. Swan. Plastics, the environment and human health: current consensus and future trends. Philos. Trans. R. Soc. B Biol. Sci., 364 (2009), pp. 2153-2166.
[26]A. McIlgorm, K. Raubenheimer, D.E. McIlgorm, R. Nichols. The cost of marine litter damage to the global marine economy: insights from the Asia-Pacific into prevention and the cost of inaction. Mar. Pollut. Bull., 174 (2022), Article 113167.
[27]Thompson, R. C., Courtene-Jones, W., Boucher, J., Pahl, S., Raubenheimer, K., & Koelmans, A. A. (2024). Twenty years of microplastics pollution research—what have we learned? Science. https://doi.org/10.1126/science.adl2746
[28]Centre for International Environmental Law (CIEL). (2019). Plastic & Climate: The Hidden Costs of a Plastic Planet. Accessed at https://www.ciel.org/reports/plastic-health-the-hidden-costs-of-a-plastic-planet-may-2019/
[29]Ibid.

4.2 Economic and social impacts and opportunities

The upstream and midstream economic impacts of non-functional slack filling include the costs to produce excess packaging and transport and store goods. Due to the linear nature of the current system (i.e., take-make-waste), there are significant losses to the economy at the end of the product's life cycle. For instance, after a very short first use, 95% of the aggregate value of plastic packaging is lost to the economy, equating to a loss of $80 billion to $120 billion USD per year.[30]

Reducing the non-functional empty space inside product packaging could present an economic opportunity for the brand-owners of plastic products. For example, by using less packaging material, brand-owners can lower material costs, potentially saving millions in production expenses.[31] Additionally, with smaller, more efficient packaging, transportation costs can be reduced as more items can be transported in fewer shipments, leading to lower fuel consumption and shipping fees.[32] This streamlining of logistics can improve supply chain efficiency and reduce operational costs.

Non-functional slack fill can mislead consumers, making products appear larger than they are, which may lead to consumer dissatisfaction.[33] Already, several class action lawsuits have been filed by consumers against large corporations for misleading packaging. Reducing the non-functional space in products could be an opportunity for brands to be more transparent with their packaging, potentially enhancing brand trust and loyalty.

As consumer preferences shift toward sustainability, companies that take proactive steps to reduce waste may also find themselves in a stronger competitive position, tapping into new markets and attracting environmentally conscious customers. However, companies must be cautious to avoid greenwashing—falsely promoting sustainability claims—when making changes to reduce non-functional slack fill, as consumers and regulators are increasingly scrutinising environmental claims.[34]

These cost savings and market advantages can help companies maintain profitability while aligning with global efforts to reduce plastic pollution.

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[30]Ellen MacArthur Foundation, "New Plastics Economy 2021 Recycling Rate Survey results summary". Available at https://emf.thirdlight.com/link/glw5k7awhdym-qfl3fa/@/. See table 1, pp. 5–6.
[31]The Consumer Goods Forum's Plastic Waste Coalition of Action. (2022). The Golden Design Rules. In The Consumer Goods Forum's Plastic Waste Coalition of Action.
[32]Ibid.
[33]Wilkins, S., Beckenuyte, C., & Butt, M. M. (2016). Consumers' behavioural intentions after experiencing deception or cognitive dissonance caused by deceptive packaging, package downsizing or slack filling. European Journal of Marketing, 50(1/2), 213–235. https://doi.org/10.1108/ejm-01-2014-0036
[34]Australian Competition and Consumer Commission. (2023). Greenwashing by businesses in Australia. In accc.gov.au. https://www.accc.gov.au/system/files/Greenwashing%20by%20businesses%20in%20Australia.pdf

Image: World map of plastics (Parilov via Adobe Stock)

4.3 Impacts to society

Waste management and recycling

The reduction in packaging waste reduces the burden on waste collection services. Fewer materials to collect, transport, and process means reduced operational costs for local governments and waste management companies. This could potentially translate into reduced costs for waste disposal and recycling, which are often borne by municipalities and passed on to taxpayers. Additionally, reducing the volume of plastic waste can help extend the lifespan of landfills, delaying the need for costly expansions or the creation of new waste disposal sites.[35]

Recycling systems would also benefit. With less plastic entering the waste stream, recycling facilities would experience lower contamination rates, improving the efficiency and effectiveness of sorting and recycling processes. This could lead to lower costs for operating recycling plants and increase the profitability of recycling operations, as cleaner and more valuable materials are easier to process and sell.

Human health concerns

There is also growing recognition that chemicals in plastics are impacting human health. There are over 16,000 chemicals used in plastics which allow plastic to be versatile and widely used. However, 4,200 of these chemicals are considered to be highly hazardous and linked to human health, and at least 11,000 of these chemicals have not been assessed for human health impacts.[36]

Exposure to major classes of plastic-associated chemicals has been found to impact human health at all stages of life including in utero, birth, childhood, and adulthood.[37]

We must take a precautionary approach to protect our environment and our communities, which means reducing the production of plastic where possible, eliminating non-functional slack fill, and removing harmful chemicals from all plastics.

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[35]Potential for waste prevention and resource conservation by reducing excessive packaging, Study by the Institute for Energy and Environmental Research and the Society for Packaging Market Research on behalf of the Federal Association of Consumer Organizations (vzbv)

[36]Lowery, T. (2024, April 23). 7 Ways Plastic Is Poisoning Us (That You Probably Didn't Know). Global Citizen. https://www.globalcitizen.org/en/content/facts-plastic-pollution-health/

[37]Symeonides, C., Aromataris, E., Mulders, Y., Dizon, J., Stern, C., Barker, T. H., Whitehorn, A., Pollock, D., Marin, T., & Dunlop, S. (2024). An Umbrella Review of Meta-Analyses Evaluating Associations between Human Health and Exposure to Major Classes of Plastic-Associated Chemicals. Annals of Global Health, 90(1), 52. https://doi.org/10.5334/aogh.4459

4.4 Case studies: Potential impact of reducing non-functional slack fill

Example 1: Cleaning products

Here we deep dive into one example of non-functional slack filling from Australia to investigate how much packaging waste could be minimised by reducing non-functional slack fill.

Figure 1: A brand new Tide Pod package with 16 capsules (left) and a measurement of headspace between the capsules and the zipper (right)

Tide pods are a brand of dish-washing detergent pods. The packaging is labelled as containing 13 oz (~384 mL) of product, however the measured volume of water that the package can contain was over four times that amount (1600 mL), resulting in an estimation of 75% slack fill. Further examination revealed that two full packages (32 capsules in total) could fit into one, with space left to reseal it (Fig 1 and 2). Although machinery requirements might make some slack fill necessary, this demonstrates the excessive non-functional slack fill in the current design. Even with practical constraints, a significant reduction in packaging volume is feasible. Reducing the packaging by 75% could still accommodate the same 16 capsules per package.

Illustrating the impact

The current Tide Pod package has two rectangular sides (20 x 22 cm) and a bottom (20 x 9 cm), totaling 1060 cm^2 of plastic. If the packaging were reduced by 50%, this would use only 265 cm^2 of plastic. In 2021, the Australian Bureau of Statistics reported about 10 million households in Australia. If each household purchased one Tide Pod package, at the current size, this would result in 2.22 km^2 of plastic waste.

Figure 2: Two packages of Tide Pods (32 capsules) fit into one package that can be resealed with the package zipper

Reducing the packaging size by 75% would bring that down to just 0.556 km^2, a difference of 1.67 km^2 of plastic waste avoided. This substantial reduction would ease the burden on waste management systems and decrease the environmental footprint of consumer goods packaging.

This example demonstrates how addressing non-functional slack fill on a large scale could play a critical role in reducing plastic waste, aligning with broader sustainability goals and supporting efforts to combat plastic pollution globally.

Example 2: food products

Non-functional slack fill is not limited to cleaning products. A confectionery item from Australia, Lindt Lindor Assorted Chocolates (11 chocolates per package), was also identified as having excessive slack fill with an estimated 89% of the package space unused. Upon further investigation, it was demonstrated that 82% of a second package (9 additional chocolates) could fit into one package while still being resealable (Fig 3 and 4). This highlights how factors like product shape, size, and density can affect packaging efficiency. Despite these variations, this example underscores the potential for significant reductions in packaging, even with complex or delicate products.

In 2023, Lindt & Sprüngli had estimated sales of over $6 billion USD worldwide[38] and states that they "proactively challenge [their] entire packaging portfolio and endeavour to reduce the amount of packaging materials used, increase the recycled and sustainably certified content, and achieve recyclability."[39] Reducing non-functional slack fill in their packaging would help them to achieve this sustainability goal and provide an opportunity to reduce their packaging costs.

Figure 3: New Lindt Assorted Chocolate package (left) and the headspace above the products (right).

Figure 4: Lindt Assorted Chocolate package containing 9 additional chocolates and resealed (left). Right: a full Lindt package with 9 additional chocolates (left), and an empty package with 2 remaining chocolates placed in front (right).

These case studies show two examples of how packaging could be significantly reduced without altering consumer experience. These examples clearly highlight the excessive use of non-functional slack fill and an opportunity for packaging reforms to address this issue.

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[38] https://www.statista.com/statistics/235844/total-global-chocolate-sales-of-lindt/

[39] Sustainability Strategy - Contributing to an Intact Environment | Lindt & Sprüngli. (n.d.). https://www.lindt-spruengli.com/sustainability/sustainability-strategy/intact-environment

5. Suggested actions

5.1 Decision-makers

1

Legislation to limit non-functional slack filling
Introduce national and international regulations or laws that mandate product design requirements with a maximum allowable percentage for non-functional space. These laws could be similar to the Food and Drug Administration's (FDA) regulations in the United States. This is something that could be addressed globally via provisions in the global plastic treaty currently under negotiation. Some countries have taken legal action in an attempt to curb non-functional slack fill nationally. For example, in the United States of America, the FDA ruled that food packaging is misleading if it does not let consumers view the contents fully and contains slack fill that is not functional.[40]

2

Need for international standards
Establish clear, globally recognised definitions and guidelines for functional and non-functional slack filling. This will provide a consistent framework for regulation and enforcement. For example, the Consumer Goods Forum (CGF), an organisation that brings consumer goods retailers and manufacturers together globally, developed “Golden Design Rules” for the design of plastic packaging, created to accelerate progress towards using less and better plastic.[41] Golden Design Rule #3 is focused on eliminating excess headspace for all flexible pack types, such that the maximum headspace is 30% or less.[42] Design rules and standards such as this could be mandated to reduce non-functional slack fill.

3

Mandate transparency in packaging
Require packaging producers to clearly indicate the percentage of functional and non-functional space in their product. This would simultaneously increase transparency in the packaging sector and empower consumers to make informed choices. This could be included in a "Digital Product Passport".

4

Incentivise re-design of packaging to be more sustainable
Create tax incentives or grants for companies that significantly reduce non-functional slack fill and adopt more sustainable packaging practices.

5

Integrate slack fill reduction into national action plans
Include measures to address non-functional slack filling in a country's national action plans, including as a method to reduce plastic production, use and pollution.

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[40]United States Food and Drug Administration Code of Federal Regulations Title 21. Volume 2 (2024). https://www.accessdata.fda.gov/scripts/cdrh/cfdocs/cfcfr/CFRSearch.cfm?fr=100.100
[41]Packaging Design. (2024, October 10). The Consumer Goods Forum. https://www.theconsumergoodsforum.com/environmental-sustainability/plastic-waste/key-projects/packaging-design/
[42]Ibid.

5.2 Plastic producers and users

1

Packaging audits
Regularly assess product lines to identify and eliminate instances of non-functional slack filling, prioritising products with the highest percentages of excess space.

2

Invest in innovative packaging design
Develop new packaging solutions that minimise non-functional space while maintaining product protection and quality. This process should involve consultation with relevant stakeholders including users and waste management facilities to ensure products retain their necessary functions, while ensuring they can be recycled after use.

3

Adopt flexible packaging systems
Use adaptable packaging systems that allow for varying product volumes, reducing reliance on one-size-fits-all packaging and minimising excess space. Modern filling machines can be reprogrammed and adjusted with interchangeable components to accommodate different product volumes within the same type of packaging material, enabling brand-owners to match packaging size precisely to product volume. This flexibility removes technical barriers to reducing unnecessary packaging, supporting more sustainable choices.

4

Collaborate with retailers and distributors
Work with partners in the supply chain to optimise packaging for transportation and display while minimising non-functional space.

5

Educate consumers on packaging choices
Provide clear information about the correct way to dispose of packaging material. Of the 80 products sampled, just over half (41) had recycling information on their packaging including recycling instructions, iconography or slogans such as “keep your country clean”. Where products cannot be redesigned and must use plastic, producers should include clear disposal instructions on the packaging material. There is an opportunity to include information on how reduced slack fill contributes to sustainability, potentially turning this into a marketing advantage.

Image: Packaging manufacturing (Industrieblick via AdobeStock)

6. Calls for further research

This is a pilot study and while it provides valuable insights, it is important to acknowledge its limitations. The data is exploratory in nature, and further research is needed to fully understand the scale and implications of non-functional slack fill across a wider range of products and regions.

However, this study demonstrated that citizen science combined with robust analysis and data quality assurance can be utilised to conduct a large-scale global study to identify instances of slack filling while minimising costs. The consistency of these findings across multiple countries highlights the urgency of addressing this issue. Waiting for more comprehensive studies should not delay action, as excess packaging contributes significantly to plastic waste, environmental degradation, and resource inefficiency.

7. Conclusion

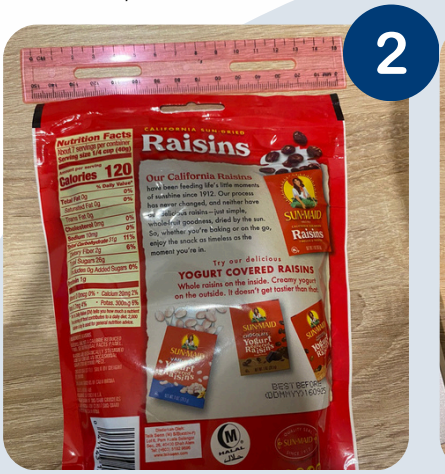
Moving forward, addressing non-functional slack fill through improved packaging design and stricter regulations could reduce waste, reduce carbon footprints, and enhance consumer trust. Encouraging brand-owners to adopt more sustainable practices by minimising slack fill and exploring alternative packaging materials could play a key role in reducing the environmental impact of these products. We therefore encourage negotiators of the global plastic treaty to address this topic and include it in the currently discussed global binding instrument while concrete details on the described measurements need to be developed at a later stage.

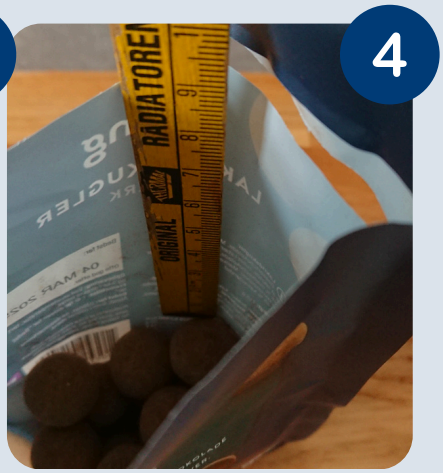
Image: Captain Billy's Landing Clean-up (Tangaroa Blue Foundation)

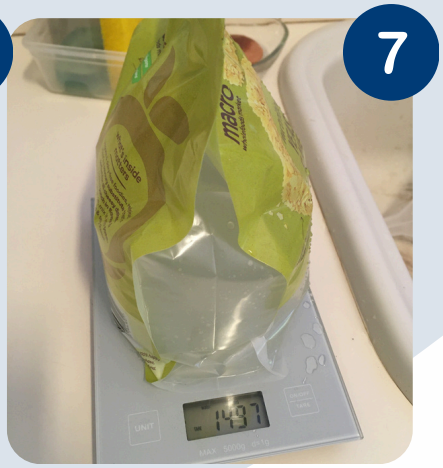
8. Methods

8.1 Data collection

Entries for this study were collected through a citizen science campaign. Citizen scientists were asked to document instances of non-functional slack filling by following the specified methodology below and recording their data within a structured survey (SI1). Slack fill was defined according to the definition by the FDA, see Box 1.







Gallery: Steps 1-3: Dimensions, 4: Inner dimensions, 5: Weigh product, 6-7 Package capacity

8.2 Data analysis

Citizen science data was reviewed by Tangaroa Blue Foundation for data entry errors. The study received a total of 86 submissions from citizen scientists across various countries. Of these, six submissions were excluded from the analysis as they did not meet the measurement criteria for slack filling or had data entry errors. As a result, 80 submissions were included in the final analysis, representing various product categories and highlighting a range of non-functional slack filling instances.

The final submissions came from fourteen countries, including Argentina (20), Australia (16, including 9 from the Australian Indian Ocean Territories), Austria (1), Belgium (3), Croatia (2), Denmark (2), Germany (1), Indonesia (13), Italy (1), Malaysia (6), the Netherlands (5), Portugal (1), Russia (2) and South Africa (9). The products measured are from 76 different companies, which in turn are owned by 25 parent companies (SI2).

9. Results

9.1 Product and packaging summary

Of all products assessed, the majority had some level of non-functional slack fill, with 62% of the products exhibiting more than 50% surplus packaging. Slack fill was defined according to the definition by the FDA, see Box 1. Some categories, such as snacks and confectionery, have particularly more excess packaging, with several items showing surplus levels of 90% or greater. On average, 67% of the packaging volume across all products is surplus, meaning that only about 33% of the packaging is used to contain the actual product. The highest recorded surplus was 96% for condiments and snack food items, while only 8 out of the 80 items analysed had a surplus below 30%, the CGF's recommended design standard.

The packaging recorded included soft plastic, a combination of soft plastic and metal, hard plastics, cardboard, multi material sachets (paper, aluminium and plastic composite), aluminium, #7 plastic, #4 plastic and foil. 41 of the 80 entries provided advice on how to recycle the packaging.

The items sampled were categorised into beverages (9), cleaning products (5), condiments (14), confectionery (18), dog treats (1), nuts and cereals (23), snack foods (11) and vitamins (1).

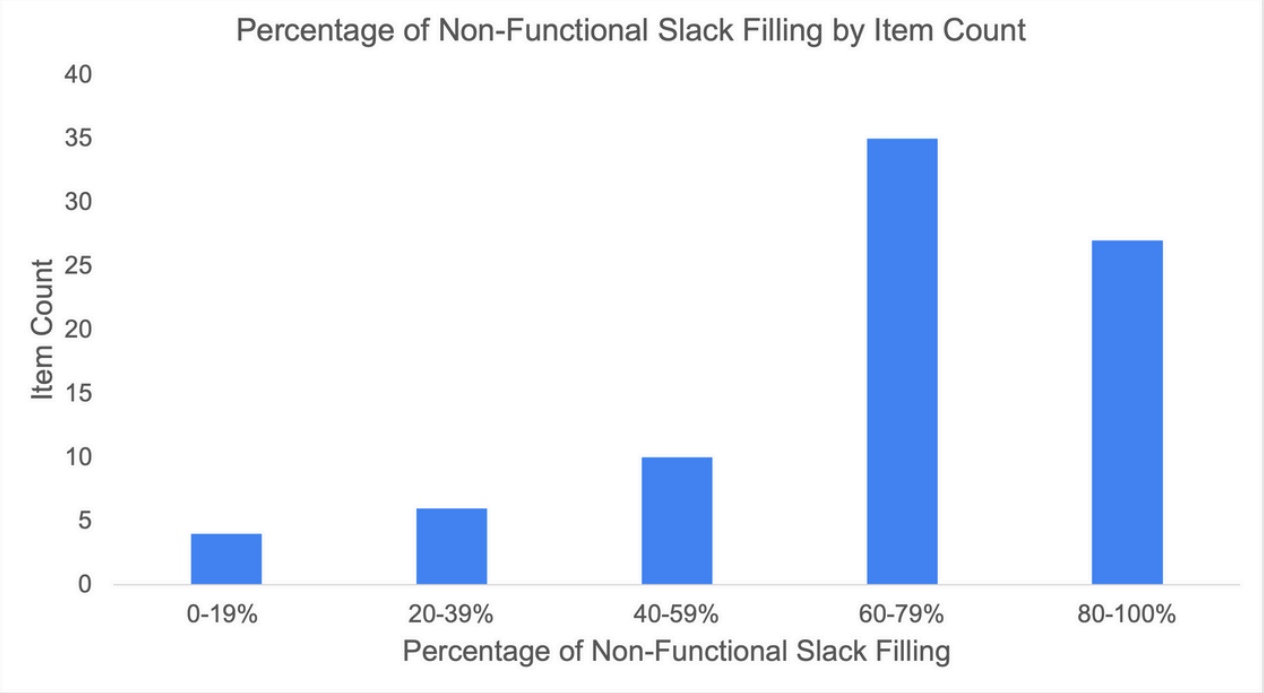


Figure 5. Percentage of non-functional slack filling by item count

Packaging was recorded in grams or millilitres depending on the product sampled. The prescribed weights of the packaging ranged from 2.7 grams to 1000 grams (1kg) and 58 millilitres to 1300 millilitres (1.3 L). Of the 80 items, 41 of the packages had identified materials for recycling, including disposal instructions, recycling iconography and keep your country clean slogans.

9.2 Products by category

Beverages

Analysis of beverage packaging includes **11 samples from 4 countries**. Beverage samples consist of coffee, tea, juice powder, sports drinks, and other powdered beverages. **91% of the items sampled** had more than **50% surplus packaging**, with some items showing surplus levels as high as 86%. This shows that 10 out of 11 of these products could reduce their plastic use by half.

One-third of the products used an excess packaging volume of **73% or more**, indicating that the packaging used for these beverages far exceeds the functional requirements for holding the product. On average, the **products had a 67% surplus**, meaning that two-thirds of the packaging volume is non-functional.

Beverage							
Country	Brand	Item	Packaging Type	Vol of Product (ml)	Vol of Package (ml)	Surplus (ml)	Surplus (%)
Argentina	Arcor	Juice powder	Soft plastic	19	50	31	62
Australia	Aik Cheong	Milk tea	Soft plastic	331	2500	2169	87
Australia	Coles	Organic Maca powder	Soft plastic	154	500	346	69
Indonesia	Agel	Bontea green	Soft plastic	143	416	273	65
Indonesia	Nestlé	Coffee mate	Soft plastic	97	262	165	62
Indonesia	Yupi	Iced cola	Soft plastic	45	95	50	52
South Africa	Mastertons Coffee & Tea Specialists	Coffee beans	Aluminium, paper and soft plastic	250	926	675.2	73
South Africa	Jacobs Kronung	Instant coffee	#90C/LDPE plastic	229.5	1500	1270.4	84
South Africa	Nescafe	Soluble coffee	#7 plastic	241.3	1475	1233.7	83
South Africa	Isotonic Game	Powdered sports drink	Aluminium	80	171	91	53
South Africa	House of Coffees	Hot chocolate	#7 plastic	499.3	730	230.6	31

Condiments

In total, **14 condiment products** were measured from samples collected from **5 countries**. The condiments sampled include sauces, seasonings, yoghurt starters, and baking products. **64% of the items** had more than **50% surplus packaging**, with the highest surplus reaching **96%**. On average, the surplus across all condiments is **57%**, indicating that over half of the packaging volume is non-functional. Some products, like the **Ivan Pole Bacterial Yoghurt Starter and the Gravox Diane Sauce**, showed a significant **96% and 87% surplus** respectively.

Condiments							
Country	Brand	Item	Packaging Type	Vol of Product (ml)	Vol of Package (ml)	Surplus (ml)	Surplus (%)
Argentina	Maggi	Mashed potato	Soft plastic	125	659	534	81
Argentina	Carrefour	Sugar	Soft plastic	1009	1458	449	30
Argentina	Royal	Baking powder	Soft plastic	51	147	96	65
Argentina	Campagnola	Filetto sauce	Soft plastic	326	407	81	19
Argentina	Knorr	Filetto sauce	Soft plastic	323	381	58	15
Australia (IOT)	MasFood	Salted chilli paste	Soft plastic	128	520	392	75
Australia (IOT)	Desa Southern Food	Sweet & sour sauce	Soft plastic	57	400	343	86
Australia (IOT)	Cerebos	Gravox sauce	Soft plastic	31	250	219	87
Australia (IOT)	Ajinomoto	Tom yam seasoning	Soft plastic	73	200	127	63
Australia (IOT)	Candy city	Curry paste	Soft plastic	39	150	111	74
Netherlands	Bio+	Pumpkin soup	Soft plastic	557	726	169	23
Russia	Ivan Pole	Yoghurt starter	Foil	30	800	770	96
South Africa	Marina	Salt	Soft plastic	507	548	41	7
South Africa	The Kitchen	Chicken A La King Sauce	Composite	57.7	218	160.3	74

Confectionery

18 confectionery products from **10 countries** were measured. The products include chocolates, candies, cookies, and jelly powders, all of which demonstrate considerable packaging inefficiencies. **94% of the confectionery** items had more than **50% surplus** packaging, with the highest observed surplus being **89%** for Lindt Lindor Assorted Chocolates, Julie's Chocolate sandwich, and Nutrijell Agarasa. On average, the products in this category show a **surplus of 70%**, indicating that the majority of packaging is non-functional.

Confectionery							
Country	Brand	Item	Packaging Type	Vol of Product (ml)	Vol of Package (ml)	Surplus (ml)	Surplus (%)
Argentina	9 de Oro	Cookies	Soft plastic	154	908	754	83
Argentina	Exquisita	Cookie dough	Soft plastic	302	735	433	58
Australia	Lindt	Lindor Assorted	Soft plastic	130	1200	1070	89
Australia (IOT)	Community Co	Melting moments	Hard plastic	196	1000	804	80
Australia (IOT)	Julie's	Chocolate sandwich	Soft plastic	93	850	757	89
Belgium	Carrefour Sensation	Crunchy chocolate	Soft plastic	508	2061	1553	75
Belgium	NV Mars Belgium	M&M's salted caramel	Soft plastic	202	456	254	55
Croatia	Mars Balkan East	Skittles crazy sours	Soft plastic	95	313	218	69
Denmark	Eliza Chookola de, Salling	Lakrids Kugler (liquorice balls)	Soft plastic	115	384	269	70
Denmark	Haribo Lakrids A/S	Salt Bomber	Soft plastic	124	338	214	63
Indonesia	Parago	Milk chewy candy	Soft plastic	62	503	441	87
Indonesia	Relaxa	Permen wangi (candy)	Soft plastic	136	443	307	69
Indonesia	Nutrijell	Agarasa	Soft plastic	10	96	86	89
Indonesia	Yupi	Neon stix	Soft plastic	47	112	65	58
Indonesia	Nutrijell	Jelly powder	Soft plastic	10	65	55	84
Indonesia	Parago	Chewy candy	Soft plastic	3	4	1	25
Netherlands	MARS The Netherlands B.V.	M & M brownie	Soft plastic	200	521	321	61
Netherlands	Cloetta Holland BV	Red Band Duo Winegums	Soft plastic	205	437	232	53

Vitamins

Measurement of **Nature's Way Adult Vita Gummies - Magnesium**, produced in **Australia**, highlights a notable packaging surplus. The product is packaged in **hard plastic**, with a product volume of 197 ml and a total package volume of 500 ml, resulting in a **surplus of 303 ml**. This means that **60% of the packaging is non-functional**, consisting of excess space.

Vitamins							
Country	Brand	Item	Packaging Type	Vol of Product (ml)	Vol of Package (ml)	Surplus (ml)	Surplus (%)
Australia	Nature's Way	Vita Gummies-Magnesium	Hard Plastic	197	500	303	60

Dog treats

Measuring **Pedigree Tasty Minis** dog treats, manufactured by **MARS Nederland**, reveals a significant packaging surplus. The product is packaged in soft plastic, with a product volume of 142 ml and a package volume of 393 ml, resulting in a **surplus of 251 ml.** This means that **63% of the packaging is non-functional** and represents unused space.

Dog Treats							
Country	Brand	Item	Packaging Type	Vol of Product (ml)	Vol of Package (ml)	Surplus (ml)	Surplus (%)
Netherlands	MARS Nederland	Pedigree Tasty Minis	Soft plastic	142	393	251	63

Nuts and cereals

23 product samples of nuts and cereals from 9 countries were measured. The nuts and cereals category includes **rice toasts, muesli, pasta, granola, nuts, and dried fruits. 86% of the products** had over **50% surplus** packaging. On average, the surplus packaging across this category is **67%**, meaning two-thirds of the packaging volume is non-functional. Several products, such as **Crisppino Rice Toasts and Cuisine & Co Corn Flakes**, show extreme surplus packaging levels of **95% and 91%, respectively**.

Nuts and Cereals							
Country	Brand	Item	Packaging Type	Vol of Product (ml)	Vol of Package (ml)	Surplus (ml)	Surplus (%)
Argentina	Crisppino	Rice toasts	Soft plastic	102	2051	1949	95
Argentina	Cuisine & Co	Corn flakes	Soft plastic	157	1936	1779	91
Argentina	Bonalma	Penne pasta	Soft plastic	495	1803	1308	72
Argentina	Luchetti	Penne pasta	Soft plastic	501	1570	1069	68
Argentina	Amici	Gnocchi	Soft plastic	518	1234	716	58
Argentina	Arcor	Polenta	Soft plastic	494	848	354	41
Argentina	Molinos Ala	Rice	Soft plastic	1005	1216	211	17
Australia	Coles	Organic coconut flakes	Soft plastic	200	1700	1500	88
Australia (IOT)	Tong Garden	Roasted almonds	Soft plastic	142	650	508	78
Austria	Spar Budget	Ofenbaguette (bread)	Soft plastic	750	1000	250	25
Belgium	Carrefour Bio	Croustillant 3 Noix (cereal)	Soft plastic	375	1424	1049	73
Belgium	Nutribel	Muesli	Soft plastic	502	1254	752	59
Croatia	Natura, marjan voce	Corn nuts	Soft plastic	62	230	168	73
Germany	Simply Sunny	Pinienkerne (pine nuts)	Soft plastic	51	159	108	67
Malaysia	Tong Garden	Salted cashew nuts	Soft plastic composite	159	610	451	73
Malaysia	Sun Gift	Dried pitted dates	Soft plastic composite	125	475	350	73
Malaysia	Sun Maid	Raisins	Soft plastic	284	630	346	54
Malaysia	Tong Garden	Honey almonds	Soft plastic composite	35	300	265	88
Netherlands	De Smaak specialist	Pumpkin seeds	Soft plastic	305	544	239	43
Russia	Snack Syla	Roasted walnuts	Soft plastic composite	104	373	269	72
South Africa	Alpen Muesli	Muesli original	Soft plastic	498	1800	1301	72
South Africa	Kelloggs	Tropical burst granola	Soft plastic	454	1420	965	67
South Africa	Futurelife	Wholegrain oats	#7 plastic	682	1900	1217	64

Snack foods

Measurements of **11 snack product samples from 5 countries** reveal extremely high levels of surplus packaging. The snack items include potato chips, crackers, dried fruit, and various regional snacks. **91%** of the snack products sampled had over **75% surplus** packaging, with some products, such as **Nikitos Fried Potato Chips and NoriGo Nori Crispy**, reaching surplus levels as high as **96%**. On average, the surplus across this category is **86%**, meaning nearly nine-tenths of the packaging is non-functional.

Snack Foods							
Country	Brand	Item	Packaging Type	Vol of Product (ml)	Vol of Package (ml)	Surplus (ml)	Surplus (%)
Argentina	Nikitos snacks	Fried potato chips	Soft plastic	100	2595	2495	96
Argentina	Gallo	Rice cookies	Soft plastic	127	1631	1504	92
Argentina	Cousine & Co	Wheat and oat snacks	Soft plastic	194	1247	1053	84
Argentina	Gallo	Spicy chips	Soft plastic	100	1137	1037	91
Argentina	Saladix	Salami chips	Soft plastic	31	246	215	87
Australia (IOT)	Nona	Tepung Goreng Pisang (banana chips)	Soft plastic	258	720	462	64
Indonesia	NoriGo	Nori Crispy	Soft plastic	21	530	509	96
Indonesia	Ajinomoto	Sajiku ikan goreng (fish snack)	Soft plastic	16	99	83	83
Italy	Solo cose buone	Crackers con pomodoro	Soft plastic	204	1898	1694	89
Malaysia	K&T World	Buah asam – dried fruit	Soft plastic	62	549	487	88
Malaysia	Tong Garden	Dried mango	Soft plastic composite	137	600	463	77

Cleaning products

The packaging of **5 cleaning products** was assessed from **3 countries**. The cleaning products sampled include detergents for household use, including general-purpose cleaning agents and laundry detergents. **60%** of the items had more than **50% surplus** packaging, with two products exhibiting surplus levels as high as **75% or more**. On average, the surplus packaging across all cleaning products is **56%**, with nearly three-quarters of the packaging volume being non-functional.

Cleaning Products							
Country	Brand	Item	Packaging Type	Vol of Product (ml)	Vol of Package (ml)	Surplus (ml)	Surplus (%)
Australia	Tide	Tide Pods (detergent)	Soft plastic	395	1600	1205	75
Australia	Cold Power	Triple Caps (detergent)	Hard plastic	268	1100	832	76
Indonesia	Unilever Rinso	Anti Noda + Molto (detergent)	Soft plastic	187	518	331	63
Indonesia	Mama Lemon	Lemak & Bau Amis Hilang (detergent)	Soft plastic	52	101	49	48
Portugal	Sonasol	Cleaning detergent	Hard plastic	1200	1500	300	20

Image: Marine debris (Tangaroa Blue Foundation)

Supplementary information

SI 1. Survey protocol for documenting non-functional slack filling - Google form

Citizen scientists were provided an instruction video to demonstrate how to correctly sample items. This video is available here. Once watching the video, citizen scientists were instructed to sample the item, provide images of the item, and answer the following questions.

The following questions were posed to participants:

1. In which country was the item purchased?
2. What is the brand of the item? (e.g., Carmans)
3. What is the name of the item? (e.g., Rolled Australian Oats)
4. What is the stated packaging content, including the unit (mL, g, kg)? (e.g., 1 kg)
5. What is the barcode of the item?
6. What is the packaging material made of?
7. Does the packaging have a window that allows the product to be seen?
8. Is there a material-type symbol printed on the packaging? If so, what is it, and participants were requested to take a photo.
9. What is the height of the packaging, including any tear strip, in millimetres (mm)?
10. What is the width of the packaging in millimetres (mm)?
11. What is the depth of the packaging in millimetres (mm)? For stand-up pouches, participants were asked to indicate the depth of the bottom of the pouch.
12. What is the diameter of the packaging if the item is cylindrical, in millimetres (mm)?
13. Does the item have a tear-off indication mark?
14. Is the packaging resealable?
15. What is the measurement from the tear strip to the top of the package in millimetres (mm)?
16. After removing the tear-off piece, what is the new height of the package (in mm) from the bottom to the new top?
17. What is the measurement (in mm) of the empty space above the product upon opening the new package directly after purchase?
18. What is the measured weight or volume of the product's content, including the unit (mL, g, kg)? (e.g., when weighing the contents of the Rolled Oats, it may weigh 1.024 kg)
19. What is the measured volume of water that the package can contain in millilitres (mL) for non-permeable packaging such as soft plastics?
20. For packaging that cannot hold water, participants were asked to use sand or flour and note which one was used. What is the measured volume of sand or flour that the package can contain in grams (g)?
21. Are there any disposal instructions printed on the packaging? If so, participants were requested to note them and take a photo.

SI 2. Parent companies of brands

This table lists the parent companies of various brands identified in the product analysis, along with a summary of the products they produce that were sampled for this study and the number of items associated with each company. The brands cover a wide range of categories including food, beverages, confectionery, household items, and cleaning products. Each parent company represents a collection of brands that are either globally recognised or regionally dominant. Items in the last category are listed under their single company or are independent.

Parent Company	Brands	Products	Count
Aik Cheong	Aik Cheong	Coffee, tea	1
Ajinomoto Co., Inc.	Ajinomoto	Seasonings, sauces	1
Arcor Group	Arcor, Campagnola, Saladix	Sweets, chocolates, snacks	7
AVI Limited	House of Coffees	Coffee products	1
Carrefour Group	Carrefour Sensation, Carrefour Bio	Supermarket goods, organic products	2
Cloetta AB	Red Band / Cloetta Holland BV	Candies, sweets	1
Coles Group Ltd	Coles	Supermarket goods	3
Ecotone (formerly Wessanen)	Bio+	Organic food products	1
Haribo GmbH & Co. KG	Haribo Lakrids A/S	Candies, gummy bears	1
Henkel AG & Co. KGaA	Cold Power	Laundry detergent	1
Independent or No Information Found	Various	Various	31
JDE Peet's	Jacobs Kronung	Coffee	1
Kellogg Company	Kelloggs	Cereals, snacks	1
Kirin Holdings	Cerebos	Salt, condiments	1
Kraft Heinz	Royal, Cerebos	Supermarket goods	2
Lindt & Sprüngli	Lindt	Chocolate	1
Lindt & Sprüngli AG	Lindt	Premium chocolates	1

Parent Company	Brands	Products	Count
Mars, Incorporated	MARS The Netherlands B.V., Mars Balkan East, Pedigree	Confectionery, pet food, chocolates	3
Mastertons Coffee & Tea Specialists	Mastertons	Coffee, tea	1
Metcash	Community Co	Supermarket products	1
Mondelez International	Cadbury	Confectionery, chocolates	1
Nestlé	Nescafe, Maggi, Nestlé, Purina, Milk Chewy Candy	Coffee, instant noodles, pet food, snacks	5
Perfect Food Manufacturing	Julie's	Biscuits, snacks	1
Procter & Gamble (P&G)	Tide	Laundry detergent	1
PT Agel Langgeng	Agel	Tea and Candy	2
Schwabe North America	Nature's Way	Supplements, herbal remedies	1
Sun-Maid Growers of California	Sun Maid	Raisins, dried fruits	1
Tong Garden Food Products	Tong Garden	Nuts, snacks	4
Unilever	Knorr, Unilever Rinso	Seasonings, laundry detergent	2