GREENPEACE

ARE WE COOKED?

THE HIDDEN HEALTH RISKS OF PLASTIC-PACKAGED READY MEALS

SUMMARY

Ready meals and takeaways promise convenience - hot food, fast. The labels on the plastic trays reassure us that they are 'safe' to heat in a microwave or oven. But are we exposed to potentially dangerous microplastics and chemical additives along with our food?

We decided to check. Greenpeace International's analysis of 24 research papers in peer-reviewed scientific journals found that the plastics we use to package our food are exposing us to health risks – and **none more so than heated ready meals and takeaways.** Specifically:

- Plastic containers can release **microplastics** and **toxic chemicals** into our food.[1]
- Leaching into food **dramatically increases when the food is heated** in the plastic packaging.

Regulators and the industry are failing to act on the plastics problem, which is already causing a global waste crisis, yet the production of plastic is set to more than double by 2050 from current levels. The fossil fuel and petrochemical industry is banking on this for its future growth – and relying on the growing trend for plastic packaged ready meals.

Past experience shows that the costs to society multiply when action is delayed by the denial of convincing scientific evidence. This has led to health and environmental disasters, from tobacco, to asbestos, to hazardous chemicals. When it comes to plastics, we already know that their global health impacts are costing trillions, and have more than enough evidence to act.

- At least 1,396 food contact plastic chemicals[2] have been found in human bodies, including several which are a **known threat to human health**, linked to conditions such as to cancers, infertility, neurodevelopmental disorders, and cardiovascular and metabolic diseases like obesity and type 2 diabetes.[3]

Current regulation is clearly insufficient to protect public health. We need to act now and apply the precautionary principle to the way that we package food and **stop this uncontrolled chemistry experiment that nobody signed up for.**

As negotiations on the UN Plastics Treaty advance, we cannot ignore the potential impacts on human health. **Reducing reliance on plastic packaging is not just an environmental issue – it is a public health imperative. And a global one.** That's why we urgently need governments to agree on a strong and effective Global Plastics Treaty.

INTRODUCTION - THE RISE OF PLASTIC PACKED READY MEALS

We live busy lives. Many people rely on the convenience of reheating plastic-packed ready meals or hot takeaways in plastic trays. But there could be a hidden cost behind this convenience – a potentially dangerous dose of microplastics and chemical additives.

To find out, Greenpeace researchers analysed 24 relevant articles available in peer-reviewed scientific journals,[4] and discovered plenty of evidence that gives cause for concern. Plastic containers, including those commonly used for ready meals, takeaways or sold as storage containers, can release microplastics and toxic chemicals into our food.[5] The research also suggests that this leaching into food dramatically increases when the food is heated in the plastic packaging.

More than seventy years since it was first made at an industrial scale,[6] fossil-fuel based plastic has infiltrated every aspect of our modern lives, and found its way into entire ecosystems and even the human body. But a big part of the plastic waste and pollution problem is not even visible. Since the first use of the term **"microplastics"** over twenty years ago, these small fragments of plastic have been found everywhere, from the deep sea to the highest, pristine mountains, in 1,300 species throughout the food web, with evidence of harm at multiple levels.[7] They are in our soil, food, water and the air that we breathe, and even in the organs and tissues of our bodies, where evidence is emerging of negative effects.[8]

There are echoes of a familiar pattern, seen in the cases of tobacco, asbestos, and lead, where corporations and governments denied scientific evidence and resisted taking action until it was too late. This failure to learn from past mistakes is now being repeated with fossil fuels and plastics. The **precautionary principle** has been adopted in order to prevent devastating damage and costs to ecosystems and people's lives, yet it still needs to be applied to these unfolding global disasters. We already know enough about plastics to act – and this is reinforced by emerging evidence that microplastics also come in the form of nanoplastics, which are much smaller and harder to identify and quantify.

Though these microplastics are a problem by themselves, plastic packaging also carries some other **unwanted passengers** in the form of chemicals. Over 16,000 chemicals are used or have been found in plastics, with at least 4,200 known to be highly hazardous to human and environmental health.[9] Some of these leak out by themselves, while some are in the microplastics that are released as the plastic breaks down.

This plastic pollution crisis is out of control, driven by the unchecked production of plastic and the huge volumes of plastic packaging thrown away every day, representing 40% of the planet's plastic waste.[10] But even before it's discarded, the plastic packaging of our food is also exposing us to health risks - and **none more so than heated ready meals and takeaways.** So it's ironic, and deeply concerning that these containers include cooking instructions to heat in the packaging "for best results" and bear the reassuring labels "microwave safe" or "oven safe"!

Plastic waste dumped in Yenidam, Adana Province, Turkey
© Caner Özkan / Greenpeace

Heading in the wrong direction

The evidence of harm from plastics and plastic chemicals is already a huge warning sign. But despite this, big increases in the production of plastics are projected. The fossil fuel and petrochemical industry is betting on increasing the volume of plastics made for its expansion; plastics are set to drive more than a third of the growth in oil demand by 2030, and nearly half by 2050.[11] This growth will depend on producing ever greater quantities of plastic packaging, and in turn, an increasing demand for ready-meals, take-aways and convenience foods packed in plastic.

"If plastics and petrochemical industries need one another, then the food system is their lifebuoy."

Joe Yates.[12]

The demand for all plastics - and its production - could more than double by 2050[13] from current (2024) levels[14]. Plastic packaging currently makes up about 36% of all plastics.[15]

Civil society rallies ahead of the Plastics Treaty in Geneva, warning of the dangers posed by the unchecked production of plastic ©Samuel Schalch/Greenpeace

The ready meals trend

Since TV dinners were introduced in the 1950's, ready meals and convenience foods have grown into a global, billion dollar market,[17] projected to grow in value from $190 billion in 2025 to $350 billion in 2034.[18] In 2024 this amounted to a global volume of 71 million tonnes, averaging 12.6 kg per person, with the cost of a ready meal and revenue per capita also expected to increase.[19]

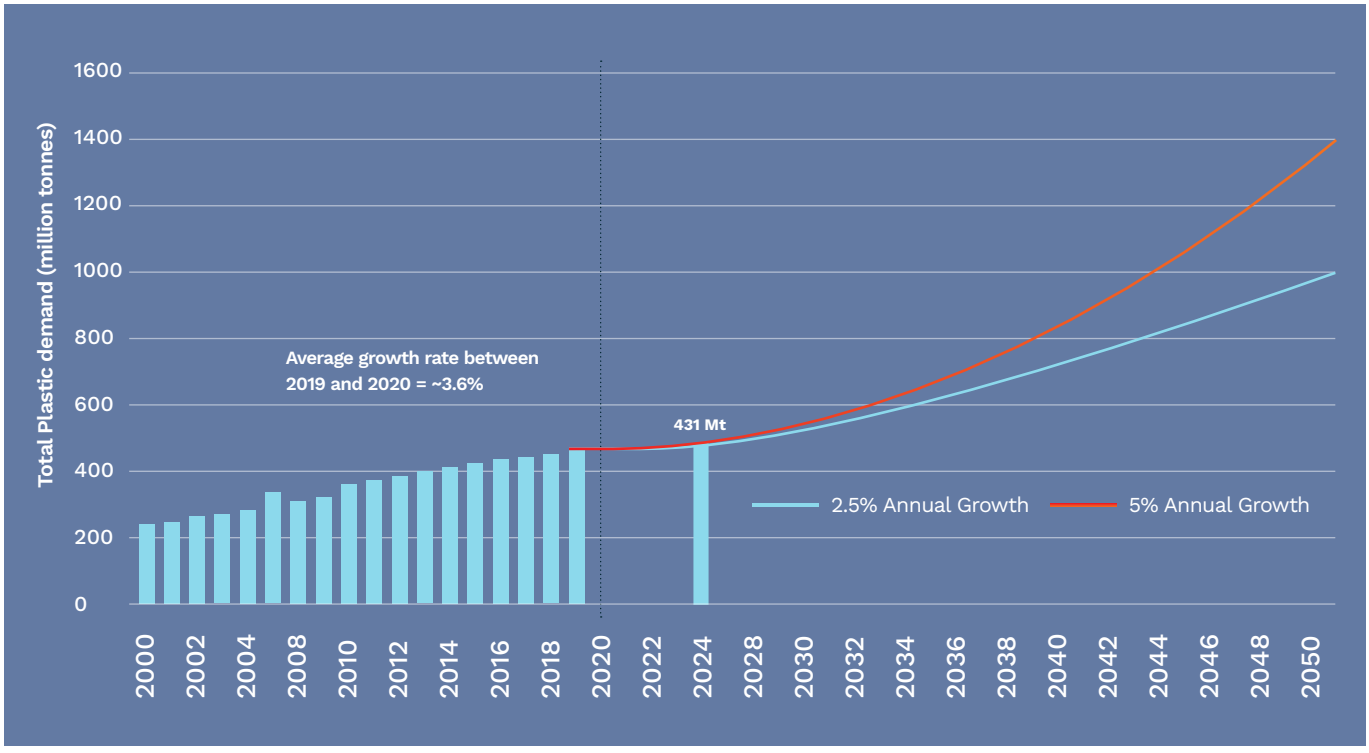

Figure 1: Projected demand growth for **all plastics** by 2050, Mt.[16]

Cooking instructions on a whole chicken labelled as **best cooked in the plastic packaging**. ©Jack Taylor Gotch/Greenpeace

A ready meal designed to be cooked in the microwave. The plastic film begins to melt under the heat. © Jack Taylor Gotch / Greenpeace © Jack Taylor Gotch / Greenpeace

Convenience meals in plastic bowls in South Korea. © Getty Images

The ready meals market is almost entirely dependent on plastic. In a study of six European countries, processed foods, such as ready meals, meal kits, and snacks, accounted for the highest levels of plastic packaging, with the UK the largest user of this type of plastic packaging.[20]

Ready meals around the world

The growing trend towards ready meals, online shopping and restaurant delivery,[21] and away from home-prepared meals and individual grocery shopping, is happening in every region of the world.[22] This includes Asia-Pacific, where local research increasingly indicates that severe nutritional deficits are associated with ready meals,[23,24] and Africa, with South Africa showing particularly strong growth of 33% year on year between 2013 and 2023.[25]

Nevertheless, it is predicted that the top five global markets for convenience food – China, the USA, Japan, Mexico and Russia – will remain relatively unchanged up to 2030,[26] with the most revenue in 2019 generated by the North America region.[27]

In Europe, this is a trend driven by the habits of Millennials and Gen Z, with 70-80% having ready meals on a weekly or monthly basis in 2025, compared with 30% of Baby Boomers.[28]

There is also increased interest in new trends such as “sous vide” appliances which offer “convenience and perfection”,[29] a cooking method where food is vacuum-sealed in a plastic pouch and cooked in a water bath at precisely controlled temperatures.

KEY FINDINGS OF STUDIES

It's well established that plastic can leach chemicals and break up into microplastics. However, our review of 24 recent articles in peer-reviewed journals highlights a consistent picture that regulators, businesses and consumers should be concerned about: that heating plastic containers in a microwave or oven significantly increases the risk that both microplastics and chemicals will be released. Much of these will leach into the food inside the packaging.

Microplastics and nanoplastics

In just minutes of heating, plastic containers can release hundreds of thousands of microplastic and nanoplastic particles.[30]

- Polypropylene and polystyrene containers filled with water released 100,000–260,000 microplastic particles after freezer or fridge storage followed by microwaving.[31] It was noted that acidic, fatty or salty foods, or using well used plastic containers might have different rates of microplastic migration.

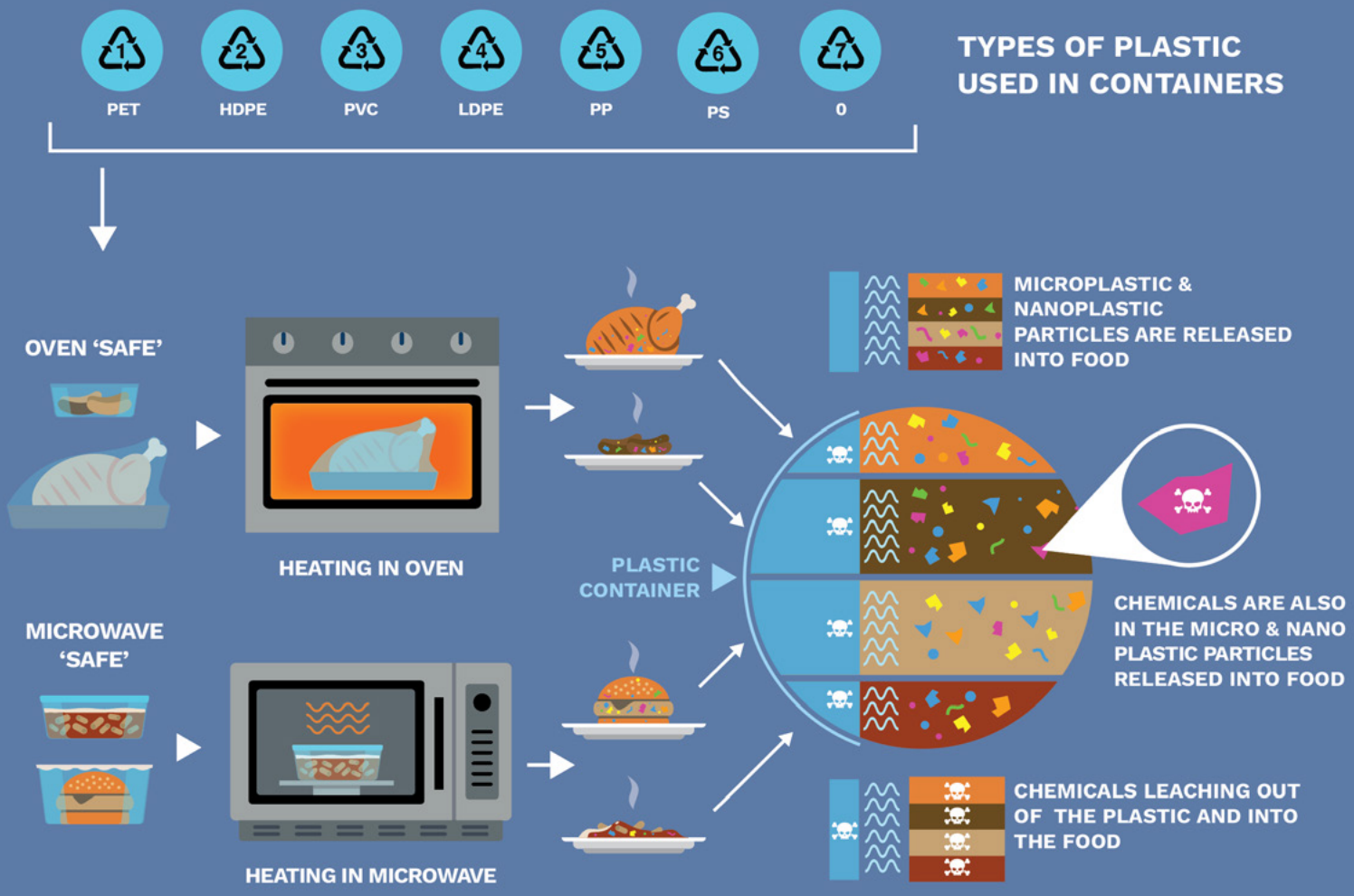

Figure 2: The hazards of heating plastic packed ready meals

- One study estimated 326,000–534,000 microplastic particles leaching into a food simulant after five minutes of microwave heating two polypropylene containers – four to seven times higher than oven heating.[32] The authors suggest that the vibration of water particles in the microwave test could explain the higher quantity of microplastics released compared to the oven test. The difficulty detecting the very smallest nanoparticles points to the possibility that more microplastics could have been released.
- Food wrap made from low-density polyethylene (LDPE), typically used to package fresh produce, meats, sandwiches and on the top of ready meals, released significantly more particles into acidic foods than into water when heated in the microwave or steamed in lab-based experiments that simulated household use.[33]
- Two studies[34] assessed the release of microplastics from microwaving after freezer storage, which suggests that freezing can make the polymer surface brittle, and that the vibration from subsequent microwaving could lead to the release of more microplastics.
- Studies have found that the power and duration of microwave use can increase the number of microplastics released from plastic food contact materials.[35,36]

A ready meal A ready meal about to be heated in the microwave © Jack Taylor Gotch / Greenpeace

There is no regulatory guidance for microplastics released from food contact materials, and although authorities acknowledge the gap,[37] cooking instructions to heat in the plastic containers are commonly found, along with misleading labels such as “microwave safe” “oven-safe” “freezer safe” and “BPA-free”, giving false reassurance.

Leaching of plastic chemicals

Each item of plastic food contact packaging also contains multiple chemicals. Some of these, like plasticisers, stabilisers, or antioxidants, are intentionally added to make the plastic functional. Others are unintentionally added, as a result of manufacturing processes, storage, or when the plastic ingredients interact with light, with food, with heat, or as breakdown compounds when the packaging starts to degrade.

More than 4,200 hazardous chemicals have so far been identified as used or unintentionally present in plastics (see Box 1). Shockingly, the majority are not regulated in plastic packaging. For those that are regulated, this is evaluated by a risk assessment (chemical by chemical), which determines “safe levels” (see ***Groundhog Day*** below).[38] Well-known hazardous chemicals such as phthalates, bisphenols, and the “forever chemicals” PFAS, associated with long term health effects such as hormone disruption, cancer, and reproductive harm,[39] leach from the packaging. Many of the chemicals that have been found to migrate into food (or food substitutes) from plastic containers have never been tested for safety.[40]

None of these chemicals are disclosed on the label, and when plastic containers are heated – especially when they contain fatty, salty, or acidic meals – these chemicals can be released into the food.[41] The review of 24 studies found:

- Chemical migration is routine, not rare.[42]
  - Broad screening confirms the scale of the issue: microwaveable plastic containers shed at least 42 intentionally added substances (IAS) and more than 100 non-intentionally added substances (NIAS) into simulants.[43]
  - In controlled microwave tests, polystyrene and polypropylene lunch boxes leached chemical additives into food simulants in every sample.[44]
  - After microwave heating, polyethylene also released antioxidant chemicals – with the highest release on first use.[45]
  - One study noted that 20 different additives migrate into the ready meal.[46]
- NIAS can form when food interacts with packaging during heating. For example, a UV stabiliser plastic additive reacted with potato starch during microwave cooking in a plastic food container to form a previously unknown chemical.[47]
- New additives, such as silver nanoparticles, increasingly added to plastic packaging to extend shelf life, were found to migrate into food during heating. These can accumulate in the liver, raising concerns over long-term organ damage.[48]

Ready meals in plastic packaging on supermarket shelves in the UK. ©Getty Images

What is a hazardous chemical?

Hazards to environment and human health include: persistence (they do not readily break down in the environment); bioaccumulation (they can accumulate in organisms, and even increase in concentration as they work their way up a food chain); and toxicity.

Some types of toxicity make it difficult to define 'safe' levels for substances, even at low doses. For example, substances may be:

carcinogenic (causing cancer); mutagenic (able to alter genes) and/or reprotoxic (harmful to reproduction); endocrine disruptors (EDCs) (interfering with hormone systems); or (persistent chemicals that spread through the water cycle).

The EU's REACH Regulation has hazard categories for classifying a 'Substance of Very High Concern' (SVHC) to be placed by the Commission on the Candidate List of substances considered for authorisation.[49]

Cooking plastic – heating increases exposure risk:

Multiple studies show that heating food in plastic in the microwave or oven dramatically increases the release of chemical contaminants and microplastics.

- Microwave heating of PP containers led to the highest quantity of micro and nano particles released into food simulants, in comparison to fridge, room temperature and high temperature storage.[50]
- Microwaved containers leached up to 534,000 microplastic particles per portion.[51]
- Antioxidants and plasticisers migrated into real food such as meat and vegetables.[52]
- Higher microwave power levels led to greater releases of microplastic particles and chemical additives.[53]
- Old or scratched containers released nearly double the microplastics compared with new ones.[54]

It should also be noted that of the 24 studies we reviewed, only two studies used real foods, with the majority using food simulants like water, acetic acid, or ethanol, which often fail to capture the reactions that occur between plastic additives and real food ingredients, and may not reflect the actual exposure levels and the diversity of harmful compounds.

Takeaways in polystyrene in Mexico. Polystryene is used globally for heating and re-heating food. © Getty Images

Hazardous chemicals and plastics

The US Food and Drug Administration (FDA) approves eight types of plastics for food storage: polyethylene terephthalate (PET), high density polyethylene (HDPE), low density polyethylene (LDPE), polyvinyl chloride (PVC), polypropylene (PP), polystyrene (PS), polycarbonate (PC), and bioplastic (polylactide). The EU also approves polyamide (nylon) and acrylonitrile butadiene styrene (ABS) for use as food containers. Melamine-formaldehyde resin (MF), can be used as tableware, in China for example.[55]

The most common plastics used for packaging food are polyethylene terephthalate (PET), polyethylene (HDPE, LDPE), and polypropylene (PP), also used for takeaways along with polystyrene (PS), due to their low cost. Microwave-ready containers are typically made from PET, PE, PP, PS or complex multilayer laminates.

All plastics consist of chemicals, from the polymer that forms the bulk material,[56] to intentionally added substances, including processing aids and chemical additives to make the plastic usable.[57] These vary according to the type of plastic, and the function of the additives. Most of the major types of plastics produced in large volumes are used in food packaging.[58]

- Chemical additives such as UV and heat stabilisers, and antioxidants, are added to most plastics.
- Some plastics also need plasticisers such as phthalates, (for example, used in large quantities in soft PVC) or flame retardants to resist heat.

Plastics that rely on the use of hazardous substances in their manufacturing process, include for example:

- PET, widely used in food packaging such as trays and drinks bottles, is made using antimony as a catalyst.

- Polycarbonate (PC), used in baby bottles and other food containers commonly contains Bisphenol A or other Bisphenols, used as a monomer in its production.
- PS, used in foam cups and other packaging, is made using hazardous styrene as a building block.

Non-intentionally added substances (NIAS), such as impurities, reaction by-products, and degradation products associated with various plastics, are also considered to be plastic chemicals.[59] Identifying these NIAS is technically complicated, as is understanding their potential risks to health: we therefore need to reduce human exposure to the many chemical contaminants in food contact materials.[60]

"Plasticisers, flame retardants, UV stabilizer - you name it. None of them are strongly bonded. They leach into us."

Dr. Sarah Dunlop, Minderoo Foundation (2024)

RESIN IDENTIFICATION CODE	TYPICAL TYPE OF PACKAGING FOR FOOD AND DRINK	EXAMPLES OF FOOD PACKAGING IN READY MEALS OR TAKEAWAYS, RELEVANT TO HEATING OF FOOD IN CONTAINERS, OR HOT FOOD.
1 PET	TRAYS, BAGS BOTTLES AND CUPS POLYMER BAGS	• REUSABLE FOOD CONTAINERS, SOLD IN STORES, LABELLED 'MICROWAVE SAFE' AND 'FREEZER SAFE'. • ROASTING BAGS FOR THE OVEN, (MADE FROM HEAT RESISTANT POLYESTER). • PET BAGS WITH "READY TO COOK" FOOD. • PET DRINKS CUP. • MICROWAVE TRAYS (MADE FROM PET).
2 HDPE	PLASTIC MILK JUGS JUICE CONTAINERS FOOD CONTAINERS	• MICROWAVEABLE FOOD CONTAINERS
3 PVC	PVC CLING FILM, OR SARAN WRAP.	• CAN BE MARKED 'MICROWAVE SAFE'. • PVC CLING FILM MAY BE USED AS A LID ON READY MEALS TO BE HEATED. • CONSUMERS MAY HEAT FOOD IN FILM.
4 LDPE	POLYMER BAGS. PE BASED REUSABLE FOOD POUCH. LDPE FILM OR FOOD WRAP, CLING FILM, SARAN WRAP (MARKETED AS A SAFER ALTERNATIVE TO PVC CLING FILM). LDPE COATING.	• POLYMER BAGS - READY-TO-COOK AND MARKETED AS TIME SAVING AND CONVENIENT. • MICROWAVE TRAYS (MADE FROM PE), CONVENTIONAL OVEN BAGS. • LDPE FILM USED ON TOP OF READY MEAL CONTAINERS (TO PIERCE WHEN HEATED). • MICROWAVEABLE FOOD CONTAINERS COATED WITH L (LDPE) OR POLYLACTIC ACID (PLA). • PAPER DRINKS CONTAINERS COATED WITH LDPE.
5 PP	RIGID CONTAINERS. LUNCH BOXES. POLYMER BAGS.	• SINGLE-USE RIGID PLASTIC TRAYS FOR READY MEALS ("MICROWAVE OR OVEN-SAFE" - USUALLY PP BECAUSE OF HEAT RESISTANT PROPERTIES. • PP POLYMER BAGS, READY-TO-COOK AND MARKETED AS TIME SAVING AND CONVENIENT • REUSABLE FOOD CONTAINERS, OR 'TUPPERWARE' SOLD IN STORES, CAN BE LABELLED 'MICROWAVE SAFE' AND 'FREEZER SAFE'. • MICROWAVE BAGS (MADE FROM PP).
6 PS	BEVERAGE CUPS FOOD TRAYS	• HOT BEVERAGES IN CUPS. • PS FOOD CONTAINERS ARE KNOWN FOR THEIR INSULATION PROPERTIES, KEEPING FOOD FRESHER FOR LONGER AT A LOWER COST . • OFTEN USED FOR TAKEAWAYS CONTAINING HOT FOOD (POTENTIALLY REHEATED IN THE CONTAINER).

Table 1: Major plastic polymers and their uses in ready meal packaging

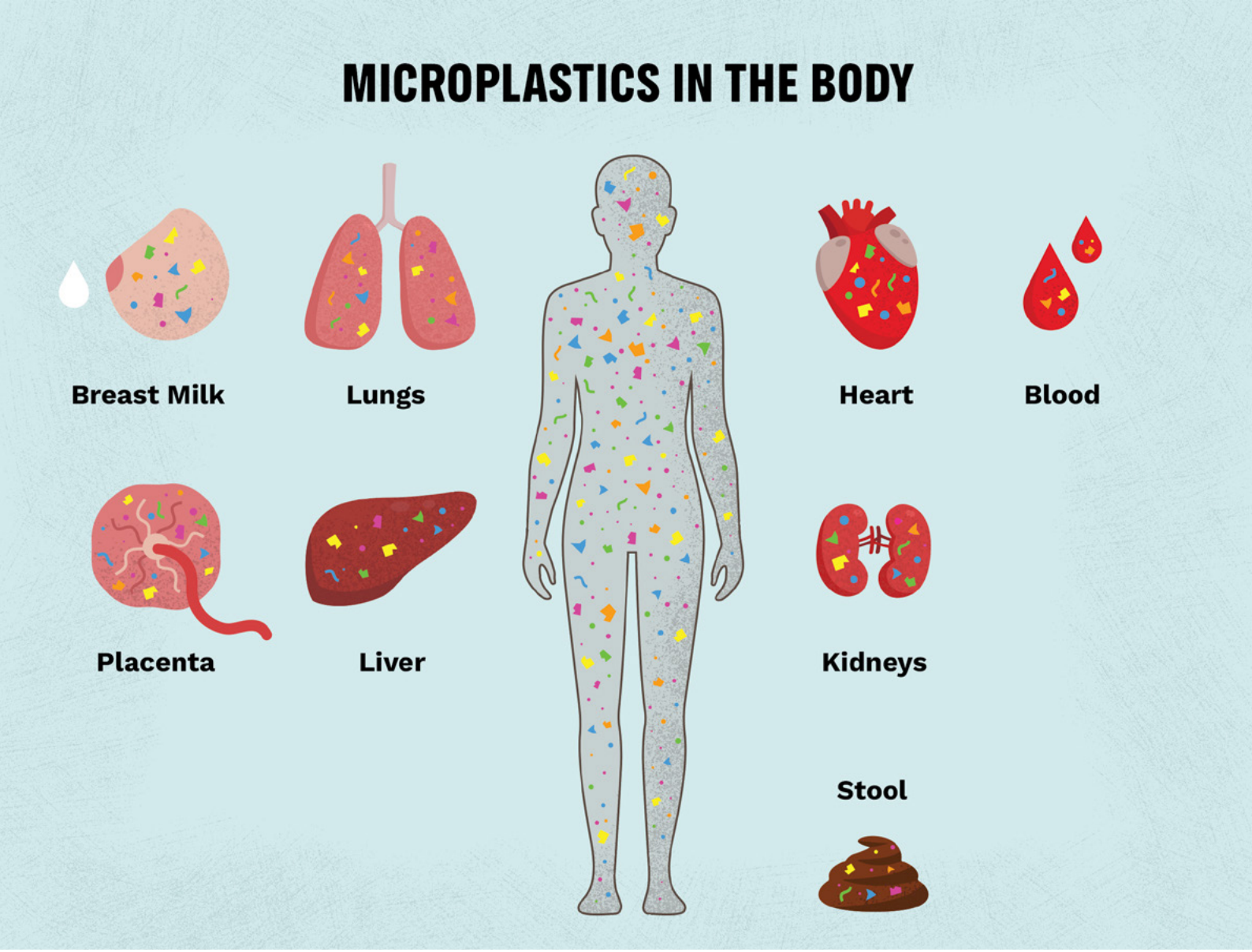

Figure 3: Where microplastics have been reported in the body

HEALTH CONCERNS: A GROWING BODY OF EVIDENCE

"Plastics are a grave, growing, and under-recognised danger to human and planetary health"

The Lancet Countdown on Health and Plastics.

Awareness of the scale of the plastic pollution problem entered the global public psyche as a result of David Attenborough's Blue Planet 2 TV series in 2017. Scientific research into the health impacts of plastics pollution has also intensified in recent years, with new studies coming thick and fast, deepening our understanding. While the science is still developing, there is already a growing body of evidence on how contaminated we've become.

The presence of microplastics or nanoplastics and plastic-associated chemicals has been reported in human blood, placenta, breast milk, amniotic fluid, stool, lungs, liver, and even heart tissue.[61] Babies may even be exposed to plastic related pollution before they are born.[62]

Furthermore, reviews and meta-analyses show that our exposure to plastics and plastics-related chemicals is associated with various worrying health outcomes.[63]

Nanoplastics impacts: When it comes to microplastics, smaller particle sizes may bring even greater threats.[64] Nanoplastics can invade cells and move through the body, including from the gastrointestinal tract and lungs to other body tissues, raising concerns both about their direct

impact on cells and the presence of harmful chemicals they contain. The evidence on micro- and nanoplastics points to worrying impacts on immune responses,[65] inflammation,[66,67] physical and functional damage to cells and tissues like the stomach lining,[68,69] and changes to the gut microbiome.[70]

There are currently no regulations to limit microplastic exposure - despite this mounting evidence of harm.

Chemical impacts: At least 1,396 food contact plastic chemicals have been found in human bodies, including several which are a known threat to human health.[71]

Plastic chemicals include known endocrine disruptors, carcinogens, and mutagens,[72] with evidence of negative impacts on health even at very low levels.[73,74]

For instance:

- Infertility and reproductive disorders - eg. reduced sperm quality, miscarriage, polycystic ovary syndrome (PCOS).
- Endocrine disruption - eg. thyroid dysfunction, obesity, diabetes.
- Neurodevelopmental impacts - eg. lower IQ.
- Non-communicable diseases including diabetes, cardiovascular disease, and many cancers.
- Alarmingly, exposure to endocrine-disrupting chemicals (EDCs) during pregnancy, infancy, and puberty can result in lifelong consequences.[75]

While more research is urgently needed, this cannot be an excuse for inaction. To prevent more damage to both our health and the planet's ecosystems we need to change course now.

Bisphenol A and Bisphenols - a story of regrettable substitutions

A case study by the Scientists' Coalition[76] on Bisphenol A found that regulating chemicals of concern in all plastics would deliver substantial health and economic benefits.

In the case of just one chemical – Bisphenol A – 97.5% of human exposure originates from plastic products such as polycarbonate baby bottles, linings in food and drinks cans and water dispensers. Considering a single health outcome (childhood obesity) where there is robust evidence, the Scientists' Coalition estimated that regulating all uses of Bisphenol A in plastics could protect up to 61,800–66,400 children from childhood obesity in the US and EU every year, saving 3.6–3.9 billion USD in associated health costs.

However, Bisphenol A is commonly substituted with other Bisphenols (BPS and BPF), which have a similar structure to BPA. Evidence has shown they also have similar endocrine disrupting properties.[77] This regrettable substitution is a common practice which risks similar negative health and environmental outcomes. Human biomonitoring studies show that 92% of adults in 11 European countries have Bisphenol A in their urine, and a follow up study in 2022 showed that median levels of BPS and BPF in urine are also increasing.[78]

Regulating all chemicals of concern as a group, such as all bisphenols, all phthalates or all PFAS, would deliver more health benefits, It would also be the most efficient and avoid regrettable substitutions.

EXAMPLES OF HAZARDOUS CHEMICALS USED IN PLASTIC	EXAMPLES OF USES /FUNCTIONS[79]	EXAMPLES OF HAZARDS TO ENVIRONMENT AND HUMAN HEALTH (SEE BOX 1)
ALKYLPHENOLS/ ALKYLPHENOL ETHOXYLATES (APS/ APES), INCLUDING NONYLPHENOLS/ NONYLPHENOL ETHOXYLATES (NPS/NPES)	ANTIOXIDANT, PLASTICISER AND STABILISER IN PLASTICS.	APS AND NPS ARE TOXIC TO AQUATIC LIFE, PERSISTENT, BIOACCUMULATIVE, AND ENDOCRINE DISRUPTORS. APES AND NPES BREAK DOWN TO APS AND NPS
BISPHENOL A OTHER BISPHENOLS	MONOMER IN PRODUCTION OF POLYCARBONATE PLASTICS AND EPOXY RESINS. ALSO USED AS PLASTICISERS.[80]	POSSIBLE ENDOCRINE DISRUPTOR. CONCERNS FOR TOXICITY TO DEVELOPMENT, ESPECIALLY IN UNBORN CHILDREN AND INFANTS. LINKED TO BREAST CANCER, PROSTATE CANCER, ENDOMETRIOSIS, HEART DISEASE, OBESITY, DIABETES, ALTERED IMMUNE SYSTEM AND EFFECTS ON REPRODUCTION, BRAIN DEVELOPMENT AND BEHAVIOUR. [81]
ANTIMONY	ANTIMONY CAN BE USED AS A CATALYST IN THE PRODUCTION OF PET PLASTIC (ALSO POLYESTER).[82]	ANTIMONY SHOWS MANY SIMILARITIES IN ITS CHEMISTRY AND TOXICITY TO ARSENIC. TRIVALENT ANTIMONY, SUCH AS IS PRESENT IN ANTIMONY TRIOXIDE, IS A MORE TOXIC FORM OF ANTIMONY COMPOUND. ANTIMONY COMPOUNDS HAVE BEEN ASSOCIATED WITH DERMATITIS, IRRITATION OF THE RESPIRATORY TRACT, AND INTERFERENCE WITH THE IMMUNE SYSTEM.
BROMINATED FLAME RETARDANTS (BFRS), POLYBROMINATED DIPHENYL ETHERS (PBDES)	FIRE RETARDANTS USED IN SOME PLASTICS AS ADDITIVES.	MANY BFRS ARE PERSISTENT AND BIOACCUMULATIVE. SOME PBDES, A TYPE OF BFR, ARE ENDOCRINE DISRUPTORS AND ARE BANNED UNDER EU LAW. THESE COULD BE REPLACED WITH ALTERNATIVE FLAME RETARDANTS WHICH MAY ALSO BE HAZARDOUS.
PER- AND POLYFLUORINATED CHEMICALS (PFAS - POLYFLUORINATED ALKYLATED SUBSTANCES)	WATER-, OIL-, STAIN- RESISTANT COATINGS. ALSO USED IN PAPER OR CARD FOOD PACKAGING.	MANY PFCS ARE PERSISTENT AND BIOACCUMULATIVE - AND ARE KNOWN AS “FOREVER CHEMICALS”. SOME CAN AFFECT THE LIVER OR ACT AS ENDOCRINE DISRUPTORS, ALTERING LEVELS OF GROWTH AND REPRODUCTIVE HORMONES.
PHTHALATES	SOFTENERS IN PLASTIC COATINGS.	SOME PHTHALATES ARE CLASSED AS REPROTOXIC, OTHERS ARE KNOWN FOR OTHER TYPES OF TOXICITY. UNDER EU REACH LEGISLATION MANY PHTHALATES ARE LISTED AS SUBSTANCES OF VERY HIGH CONCERN.
PAHs - POLYAROMATIC HYDROCARBONS	ADDED TO RUBBER AND PLASTICS AS A SOFTENER OR EXTENDER AND MAY BE FOUND IN RUBBER, PLASTICS, LACQUERS, AND COATINGS.[83]	LEGISLATION IN MAJOR MARKETS AROUND THE WORLD RESTRICTS THE PRESENCE OF PAHS IN FINAL PRODUCTS. SOME PAHS CAN BE VERY TOXIC TO AQUATIC ORGANISMS AND, ABOVE CERTAIN EXPOSURE LEVELS, MAY CAUSE LONG-TERM ADVERSE EFFECTS IN THE AQUATIC ENVIRONMENT. LONG-TERM EXPOSURE TO SOME PAHS MAY RESULT IN THE DEVELOPMENT OF PARTICULAR CANCERS.
TRICLOSAN, ALSO KNOWN AS MICROBAN	ANTIBACTERIAL ADDITIVE.	TRICLOSAN HAS BEEN REMOVED FROM THE LIST OF AUTHORISED ADDITIVES IN THE EU, BUT IT COULD STILL BE USED IN OTHER REGIONS SUCH AS THE US.[84] TRICLOSAN IS AN ENDOCRINE DISRUPTING CHEMICAL. IT MIGHT ALSO AFFECT IMMUNE RESPONSES AND CARDIOVASCULAR FUNCTIONS, AND STUDIES OBSERVED AN ASSOCIATION BETWEEN A RISE IN TRICLOSAN EXPOSURE AND REPRODUCTIVE AND DEVELOPMENTAL DEFECTS IN INFANTS.[85]

Table 2: Hazardous chemicals used in plastic and their hazards

Ultra-processed and packed in plastic: a nightmare combination

Ultra-processed foods (UPFs) and plastic packaging are co-dependent. UPFs fail to nourish. UPFs rely on plastics for cheap, long-shelf-life packaging, while plastics rely on UPFs for mass-market expansion.[86]

UPF ingredients such as emulsifiers, stabilisers, artificial colours, and sweeteners are typically made using a series of industrial techniques and processes. These ingredients are designed for shelf life and hyper-palatability, and you're unlikely to find such products in your kitchen cupboard.

The global expansion of UPFs is made possible by cheap lightweight plastic packaging. This toxic relationship fuels chronic disease, environmental destruction, and corporate profit. The health cost is staggering:

- Heating plastic-packed UPFs adds migrating endocrine disruptors, oligomers, and microplastics to an already nutritionally empty meal.[87]
- As well as their reliance on UPFs, ready meals are typically high in fat, salt or sugar.[88] Over 75 cohort studies link UPFs to obesity, diabetes, cancer, cardiovascular disease, and mental health disorders.[89, 90]
- UPFs and plastics together drive chronic disease, fossil fuel dependence, and planetary harm.[91]

We are paying a very high price for the sake of convenience, with our own health, and the health of planetary ecosystems, which are exploited, polluted and disrupted.

GROUNDHOG DAY

Why we need to act on the Precautionary Principle

We've all been here before, with asbestos, tobacco, lead. Whenever concerns about their safety were raised, again and again the industry delayed action by sowing the seeds of doubt about the science.[92] It is estimated that tobacco use caused 60 million deaths in developed countries alone between 1950 and 2000.[93] Not only that, lobbying efforts for the tobacco industry set a destructive precedent which is still impacting current action on damaging industries such as fossil fuels, undermining trust in science, confidence in the media, and the social responsibility of the corporate enterprise, which were all substantially harmed.[94] This pattern is replicated elsewhere, showing the costs of inaction to society and the environment: for example, cleaning up the unchecked hazardous chemical pollution of our rivers and waterways imposed a heavy financial burden on society, and a long lasting health burden on communities.[95] The deadly consequences were far worse because we did not act in time, and we still suffer them today.

Now plastics and plastic chemicals are following a similar trajectory.[96] In the US alone, the social cost of plastic across its lifecycle is estimated to be up to $1.1 trillion per year.[97] And the projected costs from the health impacts of just three plastics chemicals - PBDE, BPA and DEHP - were estimated to exceed $920 billion in 2015.[98] The science shows how plastics and plastic chemicals have spread through the environment and into our bodies, threatening ecosystems and our own health. While hundreds of lobbyists from the plastic industry have attempted to weaken the ambition of the Plastics Treaty negotiations by shifting attention

In 2005, pregnant women in Berlin displayed messages on their bellies outside the CDU conservative party's headquarters, calling for strong, preventive action in the EU regulation REACH. 300 industrial chemicals had already been proven to be in human blood and breast milk. © Paul Langrock / Greenpeace

onto false solutions like chemical recycling,[99] leading scientists and organisations[100] have warned that waiting for perfect evidence will lock in irreversible harm.[101]

It's time to shift the burden of proof onto those who produce, profit from, and promote products and practices that can irreversibly damage ecological systems and threaten human health. Governments have enough information to take urgent action to prevent the plastic crisis from getting worse, in line with the **precautionary principle**. Preventative measures across the plastic lifecycle are possible and required. Corporations and governments must prioritize dramatic reductions in plastic production and use, shifting away from plastic products and packaging especially food contact and child-centred products, and transitioning to non-toxic reuse systems.

The precautionary principle is not a new idea and can be found in numerous regional treaties and global conventions, from the Rio Declaration,[102] to conventions such as Stockholm, OSPAR and others, to being a fundamental cornerstone of EU environmental policy (Article 191 of the EU treaty[103]). It is also reaffirmed in the founding mandate of the Global Plastics Treaty.[104]

The EU's REACH regulation on chemicals also puts the burden of proof onto producers to provide data showing that a chemical is safe, before authorising it for access to the market. This 'no data, no market' approach provides a good example[105] of enforcing precautionary action through the 'principle of producer responsibility', placing the responsibility to prevent ecological harm in the hands of those who can make the most effective changes.

But the precautionary principle is not generally **applied to the problem of plastics.** Firstly, there is the problem of the limited hazard data and regulation of chemicals of concern in plastics, with three quarters of the chemicals found or used in plastics not even assessed.[106] Secondly, while hazardous chemicals regulated under the EU Regulation REACH are assessed for their suitability for the market based on **hazard**, which reflects a precautionary approach, this is not applied to plastics, and not required for food contact materials, which are evaluated using **risk assessment** to determine if the chemicals will leach out above so-called "safe limits". This inconsistency is even noted by the plastics industry:[107]

"... the hazard assessment under REACH (CMR, BPT/vPvB, SEC) may conclude that a substance is an SVHC on the basis of a hazard assessment but the same substance may be approved for use in food contact materials on the basis of an extensive risk assessment showing safe use levels."

Plastics Europe.

Relying on a risk-based approach allows chemicals that have already been determined as hazardous “Substances of Very High Concern” (SVHCs) under REACH (see Box 1) to be added to plastics used for food contact materials. This takes no account of the fact that some types of toxicity, such as being carcinogenic, or an endocrine disruptor, make it difficult to even define a “safe” level; very low doses can cause significant effects on the development of young children and babies in the womb. In the real world, we are also exposed to multiple combinations of chemicals in plastics: exposure to **low levels of a cocktail of chemical contaminants**, even if those levels are regarded as ‘safe’, can have negative effects,[108] another aspect not considered by the usual risk-based approach. And when chemicals are persistent and bioaccumulative, considering the risk from one dose alone is irrelevant. Unfortunately, chemicals with all of these properties were found in our review.

The same applies to plastic polymers and their inevitable breakdown into microplastics. The EU’s 2023/2055 regulation[109] restricts the deliberate use of synthetic polymer particles in a wide range of consumer products, but does not apply the same precautions to food contact materials. Furthermore, although the US FDA states that "current scientific evidence does not demonstrate that levels of microplastics or nanoplastics detected in foods pose a risk to human health", they go on to note that "there are no standardized methods for how to detect, quantify, or characterize microplastics and nanoplastics".[110]

These positions reveal a troubling policy gap: in the face of studies that consistently detect plastic particles and chemical migrants in food, regulators either deny the risk or fail to act. This disconnect highlights the importance of the precautionary principle. Waiting for irrefutable proof means that millions of people are potentially exposed to invisible harm.

CONCLUSIONS

We must not continue to sacrifice ecosystems and put our health at risk by packing our food in plastic packaging for the sake of short-term profits – then ask the taxpayer to spend billions trying to clean up the damage and cure the illnesses. **Plastic is not a special case** - it’s time to apply the precautionary principle.

Emerging evidence suggests that the plastics we use to package our food pose a hidden and potentially serious health risk – none more so than heated ready meals and takeaways.

Greenpeace International's analysis of 24 peer reviewed studies reveals that heating food in plastic containers commonly releases a worrying cocktail of chemical additives and microplastics from the plastic packaging directly into food and drink products.

When we put this emerging evidence of health risks together with the huge problem of the millions of tonnes of single-use plastics flowing into our rivers and seas every day, or breaking up into microplastics and polluting the air and soil, we can only come to one conclusion – **we need to take precautionary action on food contact plastics.**

Current regulation regimes are clearly insufficient to protect public health. We need to act now and apply the precautionary principle to the way that we deliver food and **stop this uncontrolled chemistry experiment that nobody signed up for.**

As negotiations on the UN Plastics Treaty advance, we must ensure that human health impacts are not sidelined. **Reducing reliance on plastic packaging is not just an environmental issue - it is a public health imperative. And a global one.** That’s why we urgently need

governments to agree a strong Global Plastics Treaty that:

- Cuts plastic production by at least 75% by 2040, to protect our health, our communities and planet.
- Eliminates all problematic plastics, prioritising a ban on single-use plastics and packaging, including containers for ready meals and takeaways.
- Includes provisions to phase out toxic and hazardous chemicals used in plastics production and found in plastics, and ensures these provisions can be strengthened over time, as new evidence of harm emerges.[111]
- Facilitates an at-scale, justice-centred, transition to a zero waste, reusable and non-toxic product delivery system, and packaging alternatives, including funding for upstream measures to catalyze and ensure implementation.[112]

At the national and regional level, action can and must also urgently be taken to address these health concerns. What must not happen is that policy makers and companies wait for decades - as they did when faced with emerging evidence about the health impacts of tobacco. Human health is just too precious to risk for the short lived convenience of a plastic wrapped meal.

Plastics Treaty Now Banner at INC5.2 in front of the Jet d'Eau of Geneva. © Jack Taylor Gotch / Greenpeace

RECOMMENDATIONS

Recommendations for policy makers

- **Implement the precautionary principle** to prevent the use of hazardous plastics and chemicals in food contact materials as a priority, based on their **intrinsic hazard** and not on a **risk assessment** which determines so-called safe levels.
- **Close the regulatory gaps** to protect the health of consumers from microplastics and hazardous chemicals in food packaging.
- **Prioritise** action on eliminating the use of known hazardous substances, including endocrine disrupting chemicals (EDCs).
- Stop giving false reassurance to consumers. As a priority, enact regulations to **immediately remove 'safe' statements** from packaging about reheating food, especially on ready meal packaging, including 'microwave safe' and 'oven safe'.
- **Ban single-use and plastic packaging** and put in place policies and financial incentives to support a switch to **zero waste, reusable and non-toxic packaging alternatives.**
- Fund independent biomonitoring and health impact research.
- Regulations also need to ensure that the development of "smart packaging" (new technologies to extend product quality and shelf life, for example) does not rely on plastic packaging or include chemical additives designed to migrate into the food from the plastic packaging to protect and preserve it.[113]

Recommendations for companies

- Based on the precautionary principle, adopt a commitment to phase out plastic packaging and ensure that there is **'zero release' of microplastics and hazardous plastic chemicals** from all food packaging materials into food, by developing and implementing an Action Plan with milestones to achieve this by 2035, which would include:
  - Prioritising the phase out of plastic packaged ready meals designed for reheating
  - A phase out plan for the use of all plastic in food packaging
  - Eliminating the use of hazardous chemicals in all food contact materials, through the creation of Restricted Substances Lists[114] of priority chemicals selected on the basis of hazard.
  - Switching to zero waste, reusable and non-toxic packaging alternatives,
- Stop giving false reassurance to consumers. As a priority, **immediately remove 'safe' statements** from packaging about reheating food, especially on ready meal plastic packaging, including 'microwave safe' and 'oven safe'.

A customer fills a jar with beans at a refill shop in Spain. Consumers can reduce their exposure to plastics by using safe alternatives like glass ©Getty Images

Recommendations for future research

- Scientists:
- Harmonise global methods for measuring micro and nanoplastics in food, packaging and human tissues. Develop reference standards.
- Test with a diversity of real foods, not just simulants.
- Conduct toxicological profiling of non-intentionally added substances (NIAS), oligomers, and novel additives, with a focus on hazardous characteristics (see Box 1) such as endocrine disruption, developmental toxicity, and organ accumulation.

What can we do, as consumers?

Avoiding plastic and plastic chemicals in the modern world is a challenge, as they are used in such a variety of everyday products. But alternative options do exist, and there are some steps you can take to make a difference.

- Encourage your supermarket and local restaurants and shops to cut their use of plastic and provide safer alternatives.
- Avoid buying food in plastic packaging of any kind wherever possible, especially if intended for heating in the oven or microwave.
- Where possible clean and refill reusable non-plastic containers.

If you do buy ready meals or get a takeaway that comes in plastic, making small changes to meal preparation, cooking and storage can mitigate exposure to chemical contaminants and microplastics.[115]

- Before cooking or reheating food in plastic packaging, transfer it to suitable containers such as stainless steel for the oven or microwave-safe glass for the microwave.[116]
- Avoid heating food that is covered in plastic wrap, and where practical, rinse the surface of food that has been covered in plastic wrap to remove any microplastics.[117]
- Avoid putting hot food into plastic food containers.[118]

ENDNOTES

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