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Plastic habits – an overview for the collection 'Plastics and Sustainable Earth'

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Abstract

Over the last 60 years we have modified our behavior to make use of new synthetic material produced from fossil fuels. We have incorporated it into almost every facet of our lives making us more comfortable. The production of plastic material has grown at an alarming rate and huge volumes of non-biodegradable waste now litters the surface of the planet creating a major global problem. To reverse this problem, we need to consider both obvious and novel behavior change and product development. While we are beginning to remove plastic items from the environment, we do have the responsibility to reduce the amount of new plastic material entering the waste stream. In order to achieve this, it is necessary to explore all options relating to the way we design, produce and consume products and determine what acceptable waste is. This article collection is concerned with addressing the problem by exploring a variety of topics as diverse as the history of plastic material use, behavior change, and the development of new, environmentally friendly products and their impact on the environment. The following essay outlines a few ideas that do require further scientific exploration so we can begin the process of weaning society off its current dependence on plastic products.

Keywords: Plastic, Synthetic, Consumption, Behavior modification, Habits

Introduction

"Plastic" is a word used originally to describe something that can be shaped or molded. It is often used in medicine to explain changes in the brain as it adapts to new circumstances, or in behavioural studies when organisms change their behaviour in response to new stimuli. However it is overwhelmingly today used to describe plastic materials whose form can be changed and molded and which are derived from fossil fuels. These plastic materials we have adopted to make our lives more comfortable. Our behaviour has shown such remarkable change over the last 60 years in adopting plastic material that it now reaches into every aspect of our lives. During the last decade the deleterious consequences of plastic material in the environment have also become more apparent and are contributing to the distinction of the Anthropocene era from the preceding Holocene [1]. It is found in locations as remote as the sea floor, to the surface of the ocean as well as in the tissues of wild animals. The chemicals leaching from plastic may have reproductive implications for animals and possibly the human race [2]. One alarming consequence is that these chemicals may have deleterious effects on the health of humans, as well as the animals, and of course those animals we eat. Of the 906 chemicals likely associated with plastic packaging, 63 rank highest for human health hazards and 68 for environmental hazards, 7 are classified in the European Union as persistent, bioaccumulative, and toxic, or very persistent, very bioaccumulative, and 15 as endocrine disrupting chemicals (EDCs). Thirty-four are recognised as EDCs or potential EDCs in the recent EDC report by the United Nations Environment Program. The identified hazardous chemicals are used in plastics as monomers, intermediates, solvents, surfactants, plasticisers, stabilisers, biocides, flame retardants, accelerators, and colorants, among other functions [3]. In order to reduce the negative effects of plastic on our health we need to change our relationship with it. This is a complex task [4].

A potted history of plastic

Most groups of people have exploited the plastic nature of materials [5, 6]. For example, Aboriginal people in

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Australia have used resins from plants in sophisticated ways to construct a range of tools [7]. Similar practices can be found in Indigenous civilizations around the world [8, 9]. These groups have used heat and organic carbon to mold resins from plants to make axes, spears, and buttons for clothing. One of the most versatile resins has been rubber from the rubber tree (*Hevea brasiliensis*). The rubber tree is native to South America and the original trees were in forests around the Amazon Basin. This material was important to the ancient Mayan people who used it as a component of rituals but also made it into balls [10]. Exporting the plant proved to be difficult, but in 1876 Henry Wickham exported 70, 000 seeds to Kew in London [11]. These seeds were distributed to various locations in South East Asia where approximately 4 % of the seeds germinated. Wickham's success put an end to the empires of the Rubber Barons in South America and thus began a new era in South East Asia [11].

The process that makes rubber so valuable is vulcanisation. This chemical process improves the durability of the rubber by adding new chemical crosslinked bonds between polymers. Rubber was utilised in many ways during the mid to late 1800s. One example from the 1860s is the solid rubber tires of the Penny-farthing bicycle. These tires replaced the iron-banded wooden wheels of the early velocipedes. These new rubber tires greatly improved the ride, making it a more desirable pastime for a greater number of people. Today the wide variety and styles of bicycle tires demonstrate the value of this material; however, vulcanised rubber was not the only organic plastic material that was developed during the 1800s.

During the 1820s some other plastic materials were developed from natural products. A similar product to rubber is Gutta Percha which is made from the sap of trees from the genus *Palaquium* [12]. This product is inert and is a good electrical insulator. For this reason the earliest large-scale uses were to coat the first transatlantic telegraph cables laid in 1845 [12]. Celluloid also became available in the mid-1800s in the form of Parkesine [13]. This material was used as a replacement for ivory but was also used in photography and the film industry. Cellulose and its properties were exploited in 1836. Cellulose was used to make the first thermoset plastics, and the range of products made from this material include Rayon [14] and Cellophane [15]. Importantly for our story, by 1992 cellulose for thermoset plastics could be manufactured without any organic materials.

Before World War II plastics were principally derived from natural materials. The drive for plastic material was stimulated when the United States was brought into the war and just 2 days after the Japanese bombed Pearl Harbor the use of rubber for any activity other than the war effort was forbidden in the US. The need for plastic material was driven by the loss of control of the rubber plantations in South East Asia. The hunt for plastic products from non-organic sources became serious and hence fossil fuels, mostly oil, became the main source. Since World War II the rate at which we produce plastic from fossil fuels has grown exponentially, from a tiny amount in 1950 to over 311 MT in 2014 [16].

Plastic in the environment

Our dependence on plastic from fossil fuels began in earnest in the 1960s and consequently plastic waste items have been found in the environment now for 50 years and is expected to grow by an order of magnitude unless major changes happen [17]. Continuous Plankton Recorder archives from the 1960s contain plastic [18], indicating how quickly this type of pollution accumulated in the ocean. The National Research Council (USA) Study Panel on Assessing Potential Ocean Pollutants (1975) estimated that discharges from ocean vessels, military operations, and sinking ships was responsible for 5.8 million metric tons (MT) of waste entering the ocean in 1975. Scientists were detecting and reporting waste from the early 1970s. Carpenter and Smith [19] detected fragments and pellets in surface waters in the Sargasso Sea and Carpenter et al., [20] found plastic pellets in birds near New York [21]. By the late 1970s Jewett [22] and Feder et al., [23] recorded the appearance of plastics on the sea floor in the Bering Sea and Gulf of Alaska. Jewett [22] suggested their results reflected a problem occurring in the Pacific Ocean and linked much of the refuse to countries nearer the equator. Carpenter and Smith, [19] identified polychlorinated bi-phenyls as the only known risk to oceanic wildlife at the time but plastics were quietly beginning to show their presence. It is estimated that by 2015, 8300 million metric tons of virgin plastic had been manufactured [24], with a total of 335 million metric tonnes being produced in 2015 alone [25]. As a result plastic refuse is found in most parts of the world [26] and the majority ends up in the oceans.

The number of known risks to wildlife has increased and includes all trophic levels [27]. The risks include entanglement, ingestion, absorbing leached plasticisers, ingestion of toxic chemicals adsorbed to the exterior of fragments [28], transportation of invasive organisms [29] and toxic effects from feeding disruption, declining reproductive performance, disturbances in energy metabolism, changes in liver physiology, and negative consequences from organic contaminants [27].

There is compelling evidence that discarded plastic in the ocean accumulates in various parts of the ocean, producing so called "garbage patches" that are associated with gyres. There are five major gyres, two in the

Atlantic, two in the Pacific and one in the Indian Ocean [30]. The two northern hemisphere gyres are thought to be the size of Australia and potentially represent a quarter of all floating plastic debris [30]. Polyethylene and Polypropylene plastic dominate the patch in the north Pacific, which is mostly composed of hard fragments and fishing nets [31]. The rate at which material is accumulating in the north Pacific Patch is increasing exponentially and at a higher rate than surrounding water [31].

Plastic is broadly classed as primary and secondary. The primary group consists of plastics that receive no further modification after manufacture and include pellets or nurdles and particles used in the abrasion and vanity industries [32, 33]. The range of secondary materials are those which undergo further modification during production of "things" such as containers and bottles [32, 33]. Both primary and secondary materials are found in the environment in large quantities, although some are hard to see because they are very small. These include the beads used in the abrasion and vanity industries. Micro-beads are found in toothpaste and face and body scrubs. Most of these beads get washed down the drain and into the environment.

Plastic of any type in the environment is a problem, but nurdles present a particularly vexing problem. This is because nurdles have never been used; they are a 'raw' material. They also signify our lack of care of the environment. Nurdles can be lost during manufacturing, transportation or processing. One of the earliest records was from New Zealand [34] in 1977, where concentrations were found to exceed 40,000 per linear meter of beach. Alarmingly the authors suggest that one day beaches will be made of "plastic sand." Pellets were also recorded in Lebanon [35]. Here they found nurdles on most beaches, while interviews with local manufacturers indicated that spills were routinely washed down the drain to enter local rivers. The nurdles found by Shiber [35] and Gregory [34] look very similar to those found on countless beaches today.

Life history and durability of plastic

There are many properties that make plastic desirable. These include its malleability, flexibility and durability; but these properties also contribute to plastic becoming an environmental problem. Because of its durability, it is both ephemeral (short-lived) and enduring. It will outlast its useful life, thus turning it into long-lasting waste that does not biodegrade. Single-use products are an obvious example, but there are many others we generally do not consider. We use many "short-lived" items every day, for example toothbrushes. These basic hygiene items are regularly found washed up on beaches (pers. obs.). The process of renovating houses marks the end of the usefulness of many plastic products. Plastic items used in the construction of houses include pipes and wiring, as well as household fittings such as toilet seats and cisterns. Many of these products may be replaced within 5 to 10 years of construction, especially during renovations. There are numerous products which we use without thinking of the consequences. For example, the plastic cord from a string trimmer (Invented by George Ballas in 1970), is distributed around the garden as part of its normal function. In this case the cost vs. consequence needs to be considered with the prospect of importing multiple tiny plastic fragments into the garden. Perhaps a better solution is to use a garden tool with solid blades that can be sharpened.

The development of new products needs to go beyond the qualities of malleability, flexibility and durability to include "Functional Longevity." We should be asking if we need to renew the whole product when a single part wears out and what alternatives there are to plastic products. The mechanisms that drive this process also need to be explored. The roles of the consumer and corporate entities needs to be examined along with the role of government policy in changing the materials products are made from.

Disposability vs cherished possessions

It must be acknowledged however, that plastic products have made our lives more comfortable, easier and safer. One example is a mattress. The historical equivalent would have seen us sleeping on a mattress stuffed with straw, wool or perhaps cotton, and it wouldn't have been constructed with inner springs, a much later development. The likely presence of insects both large and small that keep us awake, and scratching in old mattresses is no longer an issue. However, the loss of large mattresses poses a landfill nightmare, especially when recycling options are not available and much of the material is plastic. Another benefit of plastic products has been the significant improvements in disease control due to medical practices using single-use, sterile, plastic products in medicine that reduce the chances of cross-infection. Of course, these particular products then need to be disposed of or recycled in an appropriate and safe way. Despite these and many other advances, there are products and practices we take for granted that *could* be changed, and this begins with changing our attitudes.

The way we regard our possessions is one of the simplest changes we can make. Clocks and watches are a good example of how we have changed our relationship with possessions over the last 500 years. The first pocket watch is said to have been invented by Peter Henlein in 1510 in Nuremberg, Germany [36]. Nearby the Italians were producing clocks small enough to be worn by the early sixteenth century, while in the second half of the

eighteenth century, pocket watches were produced with three hands, thus making time-telling even more accurate [36]. These early pocket watches were practical, highly valued and also used as status symbols. Because of their intrinsic value these watches were handed on to the next generation. As the materials, technology and engineering employed in making in pocket watches was refined, and the cost came down, their general use widened to include all classes. During the First World War wristwatches became popular [37]. They were a cherished possession. Today measuring time is not difficult, and many people use their mobile phones. The fashion of wristwatches waxes and wanes. Cheap, battery operated plastic models, can be purchased for a few dollars. Although expensive brand watches remain a status symbol the cheap plastic versions are disposable [37].

The majority of the world's population now has access to television and to a lesser extent the internet. Along with the globalization of trade and mobile phones, these technologies are likely responsible for our increasing rates of consumption. As a result of our connectedness we can see news, ideas and fashion change before our eyes, in an instant. With this comes the desire for the latest of everything, and, at the touch of a button or screen, we can purchase many of these items [38]. A credit card or Afterpay facility ensures we can buy it, even if we don't have the savings [39]. One of the most obvious examples of these practices is provided by the fashion industry. The latest fashion is shown on the catwalk, while cheap plastic copies can be mass produced in vast numbers, relatively easily and quickly. Consumption of Fast Fashion rates combined with low-quality products can result in a material, often synthetic and plastic-based, being adding to the waste stream [40]. The express delivery industry also contributes waste to the environment through its packaging [41].

Habits we need to change

Social norms have changed enormously over the last 60 years. We are encouraged to consume because it drives the economy and builds our status as individuals. We all want to do what was out of reach to most of the population a few short years ago. However, there is a cost, and that is the increasing rate at which plastic material has built up in the environment - and its chemical debt, a debt that we do not yet fully understand. However public awareness campaigns have encouraged the first tentative steps towards addressing the problems.

Reversing the habits that have developed around plastic consumption requires careful consideration. Behavior change studies of the 1980s considered how age, gender, economic and cultural background, attitudes, and motivation were correlated with social consciousness and environmental concern, and by the 1990s there was a shift to activities such as recycling and social consciousness and environmental concern [42]. Recent investigations have looked at behavior change around individual items such as coffee cups [43], microbeads [4] and single use plastics [44] (as outlined further below in Fig. 1). Models such as Prochaska and DiClemente's [45] Transtheoretical Model of Behavior Change, can be used to modify consumption behavior. The model's five stages of behavioral readiness are: pre-contemplation (consumers are still not thinking about changing behavior); contemplation (consumers are seriously considering change); preparation (consumers have tried to alter behavior, and are considering trying again); action (change has occurred); and maintenance (change has been maintained). Studies such as Dorn and Stöckli [46] find that social pressure does bring about change in term of consumption, while Verfuerth and Gregory-Smith, [47] hypothesise that people who are environmentally aware are likely to adopt new habits around selecting recyclable products as part of what is termed the *Spillover Effect*. There is also a need to expand on ideas presented by authors such as Daae et al., [48], exploring their nine dimensions of behavior control, and four goals of the circular economy. However we need to take our efforts beyond single-use consumption, and explore all aspects of our lives where low-cost, low-quality disposable items can be replaced with durable products that will last a lifetime and are not subject to the whims of fashion, or be biodegradable or non-persistent materials.

Consumption patterns are often associated with traditional or cultural activities. One such event is a wedding. Gifts given at weddings were once associated with furnishing the home, but today most people are blending two households or have all the nessesary possesions, making people give items that could be superfluous. Today many people leave home to start their lives as a single person. The move is often accomplished with little ceremony and cheap brooms, mops, toasters, kitchen utensils and flat packed furniture made from low quality plastic materials are purchased. These products are often seen in curbside collection drives after a few short years, and end in landfill. We need to challenge this situation with new traditions that reflect how we can live without plastic. Perhaps we celebrate our offspring leaving home by supplying them with basic household products made from long-lasting materials. Dustpans and brushes are not glamorous items, but good quality sets that are personalised are more likely to be cherished and kept.

In the past, older family members would teach younger members skills needed to maintain clothing, toys and equipment. Today we can simply purchase new socks and toys and have no need to for skills to make things. The character "Woody" from the blockbuster "*Toy Story*" could be the pinup toy of change. There are

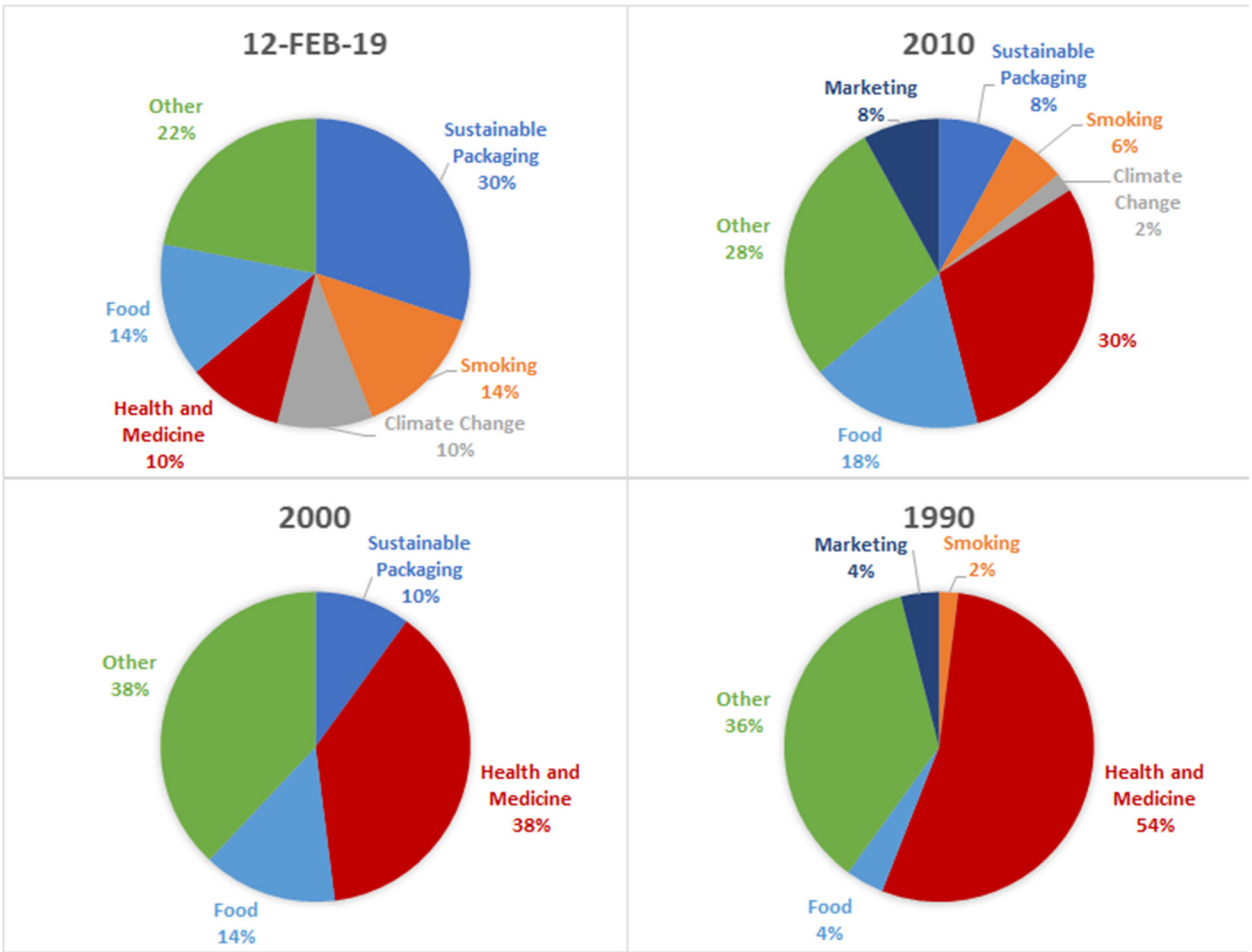

Fig. 1 Classification of the first 50 entries on Google Scholar using the search terms "Behaviour Change" and "Packaging" in 2019, 2010, 2000 and 1990. Sustainable Packaging includes all entries that included elements concerned with changing the way we interact with products that produce waste packaging

many figurines of this character available in stores and online, all of which are made from plastic. Woody is essentially a rag doll and represents an opportunity for families to make their versions of this character. It is an opportunity to learn how to sew and would give every child a unique doll. Reviving skills and making unique things that are missing in today's society.

The future

Awareness of plastic in the environment has been fuelled by an increased focus on the topic in the media. This includes programs such as the Australian Broadcasting Corporation's "War on Waste" and media focus on campaigns to end the use of single-use plastics like straws. Our response to this problem has been slow given the first articles appeared in the 1970s [22, 23, 49]. Today there are programs to reduce plastic in the ocean such as "The Ocean Cleanup" (https://www.theoceancleanup.com/) which aims to remove plastics from regions of high accumulation. A growing interest on the topic of plastics in the environment is also evident in the number of peer reviewed articles concerned with the waste issue being published in recent years [50]. Our understanding of plastic in the environment needs to expand from just exploring its distribution in the environment to improving policy and changing our relationship with plastic.

It is likely that the increase in information regarding waste in the environment has resulted from the expansion of research in the area. To examine if this is so, an internet-based assessment was conducted. The first 50 responses on Google Scholar were categorised using the search terms "packaging" and "behaviour change" for 2019, 2010, 2000 and 1990 into seven groups. The 2019 sample revealed 15 resources that were concerned with the production of waste or developing sustainable habits around packaging (Fig. 1). This is nearly three times

more than the samples from 2010 and 2000. Articles on sustainable packaging were not evident in the sample from 1990, even when the additional terms of "waste" and "recycling" were added. The high representation of articles concerned with sustainable packaging in 2019 indicates that this is an important field and thus it is possible to speculate that its importance will grow over time.

The 15 selected articles from 2019 (Table 1) cover a wide variety of topics, ranging from the way we consume coffee cups [43, 51] to the *Spillover Effect,* where environmental awareness in one aspect of life results in better practices in other areas of life [47]. Their diversity and content suggest that the task of reducing our reliance on plastic is being considered through a variety of different lenses.

Tackling the problems caused by plastic needs to be addressed from multiple levels. Vince and Stoett [62] concluded that the issue of plastic in the environment requires a holistic approach that covers global governance, science, data collection, behavioral psychology, education and changes to management and policy. However, the commitment of groups of people to managing waste differs between individuals and groups. It is perceived by the public that individuals, environment groups and scientists are among the most motivated groups to tackle the problem of plastic waste, while retailers, industry, government and policy makers, the wider general public, commercial users of the coast, and the media as a whole are less likely to be motivated [53]. The problems are further complicated by differences between people. In China, more educated people were less likely to recycle as they are not exposed to most of the pollution and do not see the urgent changes that are needed [41]. A result that is counter to what might be expected.

Changing people's behavior regarding consumption of products and increasing their likelihood of recycling requires further development. Motivating people to change requires more than one method of engagement. A reliance on written or pictorial information is not enough to significantly change people's behavior around disposing of takeaway containers. Messages needed to include environmental and financial incentives in addition to the provision of alternatives, such as coffee cups to change people's use of disposable cups [41, 43]. While changing people's behavior is complex, there are some changes that appear to be more readily acknowledged. Gabriel et al., [59, 60] found that people are more accepting of products that have been "designed for material conservation" that use recycled plastic pellets and often an intention to recycle is not supported by the act of recycling [63].

Changing our relationship with plastic material is vital if we are to reduce and stop its flow into the environment. There is a vast array of topics to research in order to facilitate this change. Some of the topics have been

Table 1 Fifteen of the first fifty entries found on "Google Scholar" on the 12 of February 2019 using the search terms "Behaviour Change" and "Packaging". These articles all cover behaviour change around sustainable packaging

Author	Title	Type
[52]	Environmental engagement through behaviour change interventions: A case study of litter reduction in New Zealand Schools	Thesis Master
[53]	Exploring public views on marine litter in Europe: Perceived causes, consequences and pathways to change	Journal
[54]	The impact of parenthood on environmental attitudes and behaviour: a longitudinal investigation of the legacy hypothesis	Journal
[41]	Impact of Information Intervention on the Recycling Behaviour of Individuals with Different Value Orientations—An Experimental Study on Express Delivery Packaging	Journal
[55]	Disentangling voluntary pro-environmental behaviour of employees (VPBE) – fostering research through an integrated theoretical model	Book Chapter
[51]	Fostering sustainable behaviour in retail: Looking beyond the coffee cup	Journal
[56]	Collective accountability needed to address waste reform and clean up South Africa	Journal
[57]	Waste sorting: A proposed social design workshop to improve behaviour and management of recycling	Thesis Master
[48]	Dimensions of Behaviour Change in the context of Designing for a Circular Economy	Journal
[58]	Direct and indirect effects of waste management policies on household waste behaviour: The case of Sweden	Working Paper
[59]	Plastic Packaging Material Value Conservation and Evident of the Consumers' Acceptance	Journal
[60]	Plastic Packaging Material Value Conservation and the Structure of Stakeholder Role	Journal
[43]	Promoting the Use of Reusable Coffee Cups through Environmental Messaging, the Provision of Alternatives and Financial Incentives	Journal
[47]	Spill over of pro-environmental behaviour	Book Chapter
[61]	Convenience or price orientation. Consumer characteristics influencing food waste behaviour in the context of an emerging country and the impact on future sustainability of the global food sector	Journal

identified in this paper, but there are many more. We have suggested changing from our reliance on disposability towards having possessions that we cherish and keep. This move requires re-thinking and modifying some older traditions in order for them to fit contemporary habits. But we also need to keep exploring the potential of new materials which we can use as an alternative to plastics [64] and reinstate some old products that we have replaced, such as leather and wood. We need new regulations [65] that modify the production of plastic to be manufactured using organic materials. As this regulatory transition occurs we need initiatives suggested by behavioral scientists to minimize plastic use and create more recycling; such approaches include visualization of the problem, understanding societal perception of the cause and effect of the issue, and education of people, particularly children [65].

The objective of the article collection 'Plastics and Sustainable Earth' is to explore the aforementioned issues surrounding plastics and how these might be overcome to further our progress toward more sustainable Earth. We need to understand the full range of plastic impacts, of plastic waste management and recycling, of plastic policy and regulation to begin the transition to non-fossil fuel-based plastic, and of plastic behavior change programs.

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References

1. Waters CN, Zalasiewicz J, Summerhayes C, Barnosky AD, Poirier C, Galuszka A, et al. The Anthropocene is functionally and stratigraphically distinct fromthe Holocene. Science. 2016;351(6269):2622–10.
2. Kumar P. Role of plastics on human health. Indian J Pediatr. 2018;85(May):384–9.
3. Groh KJ, Backhaus T, Carney-almroth B, Geueke B, Inostroza PA, Lennquist A, et al. Overview of known plastic packaging-associated chemicals and their hazards. Sci Total Environ. 2019;651:3253–68.
4. Dauvergne P. The power of environmental norms : marine plastic pollution and the politics of microbeads pollution and the politics of microbeads. Environ Polit. 2018;27(4):579–97. https://doi.org/10.1080/09644016.2018.1449090.
5. Helwig K, Monahan V, Poulin J, Andrews TD. Ancient projectile weapons from ice patches in northwestern Canada : identification of resin and compound resin-ochre hafting adhesives. J Archaeol Sci. 2014;41:655–65. https://doi.org/10.1016/j.jas.2013.09.010.
6. Fox A, Heron C, Sutton MQ. Characterization of natural products on Native American archaeological and ethnographic materials from the great basin region , U.S.A.: A preliminary study. Archaeometry. 1995;2(October 1994):363–75.
7. Pitman HT, Wallis LA. The point of Spinifex : aboriginal uses of spinifex grasses in Australia. Ethnobot Res Appl. 2012;10:109–31.
8. Pawlik AF, Thissen JP. Hafted armatures and multi-component tool design at the Micoquian site of Inden-Altdorf, Germany. J Archaeol Sci. 2011;38(7):1699–708. https://doi.org/10.1016/j.jas.2011.03.001.
9. Bradtmöller M, Sarmiento A, Perales U, Zuluaga M. Investigation of upper Palaeolithic adhesive residues from Cueva Morín, Northern Spain. J Archaeol Sci. 2016;7:1–13. https://doi.org/10.1016/j.jasrep.2016.03.051.
10. Christenson AJ. POPOL VUH Sacred Book of the Quiché Maya People. Norman: University of Oklahoma Press; 2007. Available from: mesoweb: www.mesoweb.com/publications/Christenson/PopolVuh.pdf
11. Schultes RE. The odyssey of the cultivated rubber tree. Endeavour. 1977;1(3/4):133–8.
12. Prakash R, Gopikrishna V, Kandaswamy D. Gutta-percha – an untold story. Endodontology. 2005;17(2):32–6.
13. Liebert T. Cellulose Solvents – Remarkable History , Bright Future. In: Liebert TF, Heinze TJ, Edgar KJ, editors. Cellulose solvents: for analysis, shaping and chemical modification. Washington DC: American Chemical Society; 2010. p. 3–54.
14. Kauffman GB. Rayon: the first semi-synthetic fiber product. Prod Chem. 1993;70(11):887–93.
15. Edwin J. Cellophane : the silent salesman. MRS Bull. 2007;32:2019.
16. MacArthur DE, Waughray D, Stuchtey MR. The New Plastics Economy: Rethinking the future of plastics. Chicago: Ellen MacArthur Foundation; 2016.
17. Jambeck JR, Geyer R, Wilcox C, Siegler T, Perryman M, Andrady A, et al. Plastic waste inputs from land into the ocean. Science. 2015;347(6223):768–70.
18. Thompson RC. Lost at Sea: Where Is All the Plastic? Science. 2004;304(5672):838.
19. Carpenter EJ, Smith KL. Plastics on the Sargasso sea surface. Science. 1972;175(4027):1240–1.
20. Carpenter EJ, Anderson SJ, Harvey GR, Miklas HP, Peck BB. Plastic Particles Found in Tern Pellets, on Coastal Beaches and at Factory Sites. Mar Pollut Bull. 1974;5(3):44–6. https://doi.org/10.1016/0025-326X(74)90234–3.
21. Hays H, Cormons G. Plastic particles found in tern pellets, on coastal beaches and at factory sites. Mar Pollut Bull. 1974;5(3):44–6.
22. Jewett SC. Pollutants of the Northeast Gulf of Alaska. Mar Pollut Bull. 1976;7(9):169.
23. Feder HM, Jewett SC, Hilsinger JR. Man-made debris on the Bering Sea floor. Mar Pollut Bull. 1978;9(2):52–3.
24. Geyer R, Jambeck JR, Law KL. Production, use, and fate of all plastics ever made. Sci Adv. 2017;3:1–5.
25. Plastics Europe. Plastics – the Facts 2017: An Analysis of European Plastics Production, Demand and Waste Data; Plastics Europe, Belgium, 2017.
26. Ivar do Sul JA, Costa M, Fillmann G. Occurrence and characteristics of microplastics on insular beaches in the Western Tropical Atlantic Ocean. PeerJ Prepr. 2017;5:e2901v1. https://doi.org/10.7287/peerj.preprints.2901v1.
27. Anbumani S, Kakkar P. Ecotoxicological effects of microplastics on biota: a review. Environ Sci Pollut Res. 2018;25(15):14373–96.
28. Commonwealth of Australia. Threat Abatement Plan for the impacts of marine debris on the vertebrate wildlife of Australia's coasts and oceans. 2018. Available from: http://www.environment.gov.au/marine/publications/threat-abatement-plan-impacts-marine-debris-vertebrate-marine-life
29. Eriksen M, Thiel M, Lebreton L. Nature of Plastic Marine Pollution in the Subtropical Gyres. In Hazardous Chemicals Associated with Plastics in the Marine Environment. The Handbook of Environmental Chemistry; Takada H, Karapanagioti H, Eds. Springer; 2016. p vol 78.
30. Lebreton LCM, Greer SD, Borrero JC. Numerical modelling of floating debris in the world's oceans. Mar Pollut Bull. 2012;64(3):653–61.
31. Lebreton L, Slat B, Ferrari F, Sainte-Rose B, Aitken J, Marthouse R, et al. Evidence that the Great Pacific Garbage Patch is rapidly accumulating plastic. Sci Rep. 2018:1–15. https://doi.org/10.1038/s41598-018-22939-w.
32. Bergmann M, Gutow L, Klages M, Bergmann M, Klages M. Marine Anthropogenic Litter; 2015. p. 1–447. Available from: http://link.springer.com/10.1007/978-3-319-16510-3
33. Cole M, Lindeque P, Halsband C, Galloway TS. Microplastics as contaminants in the marine environment: a review. Mar Pollut Bull. 2011;62(12):2588–97. https://doi.org/10.1016/j.marpolbul.2011.09.025.

34. Gregory MR. Plastic pellets on New Zealand beaches. Mar Pollut Bull. 1977;8(4):82–4.
35. Shiber JG. Plastic Pellets on the Coast of Lebanon. Mar Pollut Bull. 1979; 10(1):28–30. https://doi.org/10.1016/0025-326X(79)90321–7.
36. Pisano AP. Resonant-structure micromotors: historical perspective and analysis. Sensors Actuators A. 1989;20:83–9.
37. Brozek JE. The History and Evolution of the Wristwatch. Florida: International Watch Magazine. Saint Petersburg; 2004. (January)
38. Thøgersen J. Unsustainable consumption basic causes and implications for policy. Eur Psychol. 2014;19(2):84–95.
39. Hodson R, Dwyer RE, Neilson LA. Credit Card Blues : The middle class and the hidden costs of easy credit. Sociol Q. 2014;55:315–40.
40. Gwozdz W, Nielsen KS, Müller T. An environmental perspective on clothing consumption : consumer segments and their behavioral patterns. Sustainability. 2017;9:1–27.
41. Chen F, Chen H, Yang J, Long R, Li Q. Impact of information intervention on the recycling behavior of individuals with different value orientations-an experimental study on express delivery packaging waste. Sustain. 2018;10(10):1–20.
42. Trudel R. Sustainable consumer behavior. Consum Psychol Rev. 2019;2:85–96.
43. Poortinga W, Whitaker L. Promoting the use of reusable coffee cups through environmental messaging, the provision of alternatives and financial incentives. Sustain. 2018;10(3):1–10.
44. Hardy SD, Bartolotta J. Barriers and benefits to desired behaviors for single-use plastic items in Northeast Ohio ' s Lake Erie basin; 2017.
45. Prochaska JO, DiClemente CC. Stages and Processes of Self-Change of Smoking: Toward an Integrative Model of Change. J Consult Clin Psychol. 1983;51(3):390–5. https://doi.org/10.1037/0022-006X.51.3.390.
46. Dorn M, Stöckli S. Social influence fosters the use of a reusable takeaway box. Waste Manag. 2018;79:296–301. https://doi.org/10.1016/j.wasman.2018.07.027.
47. Verfuerth C, Gregory-Smith D. Spillover of pro-environmental behaviour. In: Wells VK, Gregory-Smith D, Manika D, editors. Research handbook on employee pro-environmental behaviour. Cheltenham: Edward Elgar Publishing; 2018. p. 455–84.
48. Daae J, Chamberlin L, Boks C. Dimensions of behaviour change in the context of designing for a circular economy. Des J. 2019;21(4):521–41.
49. Waldichuk M. Intergovernmental Oceanographic Commission Global Marine Pollution : An Overview. Paris: Health (San Francisco); 1977.
50. Ivar Do Sul JA, Costa MF. The present and future of microplastic pollution in the marine environment. Environ Pollut. 2014;185:352–64.
51. Ferreira J. Fostering sustainable behaviour in retail: looking beyond the coffee cup. Soc Bus. 2018;8(1):21–8. https://doi.org/10.1362/204440818X15208755029519.
52. Thomas RM. Environmental Engagement through Behaviour Change Interventions : A Case Study of Litter Reduction in New Zealand Schools, Victoria University of Wellington, Wellington, 2018.
53. Hartley BL, Pahl S, Veiga J, Vlachogianni T, Vasconcelos L, Maes T, et al. Exploring public views on marine litter in Europe: perceived causes, consequences and pathways to change. Mar Pollut Bull. 2018;133(June): 945–55. https://doi.org/10.1016/j.marpolbul.2018.05.061.
54. Thomas GO, Fisher R, Whitmarsh L, Milfont TL, Poortinga W. The impact of parenthood on environmental attitudes and behaviour : a longitudinal investigation of the legacy hypothesis. Popul Environ. 2018;39(3):261–76.
55. Hahn R, Ostertag F. Disentangling Voluntary Pro-Environmental Behaviour of Employees (VPBE) - Fostering Research through an Integrated Theoretical Mode. In Research Handbook on Employee Pro-Environmental Behaviour; Wells VK, Gregory-Smith D, Manika D, Eds. Cheltenham: Edward Elgar Publishing; 2018; pp. 83–105. https://doi.org/10.4337/9781786432834.
56. Stubbs K. Collective accountability needed to address waste reform and clean up South Africa. Civ Eng. 2018;9:29–30.
57. Ravn A. Waste Sorting Analyses. Sweden: Linnaeus University; 2018.
58. Camilla A, Stage J. Direct and indirect effects of waste management policies on household waste behaviour: The case of Sweden. Waste Manag. 2017;76:19–27.
59. Gabriel DS, Isnandar D, Jeremia A. Plastic packaging material value conservation and evident of the consumers' acceptance. Key Eng Mater. 2018;773:390–5 Available from: https://www.scientific.net/KEM.773.396.
60. Gabriel DS, Pratama BAJ, Hapsari C. Plastic packaging material value conservation and the structure of stakeholder role. Key Eng Mater. 2018;773: 396–404 Available from: https://www.scientific.net/KEM.773.396.
61. Aschemann-Witzel J, Giménez A, Ares G. Convenience or price orientation? Consumer characteristics influencing food waste behaviour in the context of an emerging country and the impact on future sustainability of the global food sector. Glob Environ Chang. 2018;49:85–94.
62. Vince J, Stoett P. From problem to crisis to interdisciplinary solutions : Plastic marine debris. Mar Policy. 2018;96:200–3. https://doi.org/10.1016/j.marpol.2018.05.006.
63. Árnadóttir ÁD, Kok G, Van Gils S, ten Hoor GA. Waste separation in cafeterias : a study among university students in the Netherlands. Int J Environ Res Public Health. 2019;16(93):1–10.
64. United Nations Environment Programme. Exploring the potential for adopting alternative materials to reduce marine plastic litter. 2018.
65. Pahl S, Wyles KJ, Thompson RC. Channelling passion for the ocean towards plastic pollution. Nat Hum Behav. 2017;1(10):697–9.

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