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A Plasticene Lexicon

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ABSTRACT

As plastic pollution in the environment has increased rapidly in the last half century, so too has the study of the effects of plastic on marine, aquatic and terrestrial ecosystems. From this research, a series of new terms has emerged to describe the phenomena unique to the presence of plastic-based materials in nature. In this short note, we bring together disparate neologisms into a single lexicon with the aim to encourage use of a unified vocabulary to describe the new reality of ecological, chemical, and geological systems in the age of plastics.

1. Introduction

New fields of endeavor − or, at least, disciplines that have enjoyed significantly increased attention − tend to generate neologisms, often as clusters of novel words to reflect new discoveries, advanced understanding, or greater resolution (McDonald, 2005; Franci, 2011). We present here a synthesis of an emerging lexicon for the study of the environmental impacts of plastic proliferation in terrestrial (land), aquatic (freshwater) and marine (ocean) habitats (Law, 2017; Harrison and Hester, 2018; Beaumont et al., 2019). We do so for two reasons. First, there is often a considerable time lag between the introduction of new words and their capture in language databases (such as *Webster's Dictionary* and the *Oxford English Dictionary*). Second, we aim to promote awareness and greater clarity of the terminology used by researchers, resource managers, policy-makers, and the general public working on environmental problems related to plastics. By concisely synthesizing new terminology and their origins, our 'Plasticene Lexicon' advances standardization of language (and subsequently the research and concepts they describe) in this rapidly accelerating field. This is an essential task as researchers, policy-makers, and managers strive for more integrated observation systems for plastic debris (Maximenko et al., 2019). We know of twelve terms (words and phrases) in the plastic neolexia (Box 1), all of which have appeared in their modern sense since 2000. We have attempted to identify those who first introduced a given term; we apologize (and welcome corrections) if we have overlooked earlier usage by others. Due to the vast and rapidly increasing literature on plastic pollution, we likely have overlooked additional new terms. Our intention is to provide a snapshot of terminology, rather than provide a comprehensive review.

2. Methods

Because of the often interdisciplinary usage of words created in response to plastics research and environmental issues, we searched (with no time limits or boundaries) for plastic-associated words, their origins, and definitions in JSTOR and in Google All, Google Books, and Google Scholar. Our search included combinations of prefixes and suffixes with "plasti" as the basal word. Where possible, we located the first apparent use of the terms in published sources, including scientific publications, books, and newspaper or magazine articles. Usage in popular-culture and social media was not assessed. Additionally, words that are commonly used to describe the chemical and physical manufacturing and labeling of plastics were not assessed.

3. Results

Plastic-related terms populate multiple fields of endeavor. Here, we organized the found terms into three categories that emerged from our search − ecology, geology, and chemistry and garbology (the study of refuse and trash). Below, we present a brief synthesis of terms for each.

3.1. Ecology of plastics

Ecological research has shed light on the ability of life to grow and proliferate on plastics. Several words have been created to describe the novel resources and ecosystems created by plastics in oceans. To a certain extent, the existence of ***epiplastic*** microbes and other organisms has been known for decades (e.g. Blumenshine et al., 1997), although this phenomenon was recently popularized with the discovery of

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Box 1
A Plasticene Lexicon
(where available, the first known usage is given)

Ecology

• ***epiplastic***, adj. (2014) living on floating plastic (Reisser et al., 2014); used earlier to refer to periphyton colonization of plastic surfaces in experimental mesocosms (Blumenshine et al., 1997).

• ***plasticized***, adj. (2014) made abstractly plastic by the proliferation of plastic pollution in the environment (Eriksen, 2014; UNEP, 2016). This stems from plasticize (v.): "to make plastic or mouldable, especially by the addition of a plasticizer" (Oxford University Press, 2019b).

• ***plastisphere***, n. (2013) the living microbiotic (Zettler et al., 2013) and macrobiotic community colonizing plastic.

• ***plastivore***, n. (2011) "The Laysan albatross is probably the most voracious plastivore on the planet" (Hohn, 2011, page 72); by extension, any organism that ingests, processes, and regurgitates or defecates plastic materials. Plastivory (n.) was introduced by John Dolan in Irigoien, 2018.

Geology

• ***plastic cycle***, n. (2019) "the continuous and complex movement of plastic materials between different abiotic and biotic ecosystem compartments, including human" (Bank and Hansson, 2019). Here, "cycle" is not only the movement of plastics, but also their origin (production and sources), evolution (changes of properties), interactions, impacts, and sinks in the environment.

• ***Plasticene***, n. & adj. (2011) an era in Earth's history, within the Anthropocene, commencing in the 1950s, marked stratigraphically in the depositional record by a new and increasing layer of plastic (Stager, 2011, attributed to Matt Dowling). The history and etymology of plasticene in this sense is not related to the word *plasticene*, a common early spelling (for example, Cooper, 1901) of the popular molding clay, plasticine.

• ***plasticrust***, n. (2019) plastic debris attached to tropical or subtropical rocky intertidal shores; crusts are variable in size, color, and thickness (Gestoso et al., 2019). This is a more focused term for Corcoran et al. (2014) "*in situ* plastiglomerate," which they defined as "molten plastic … adhered to the surface of a basalt flow."

• ***plastiglomerate***, n. (2014) "an indurated, multi-composite material made hard by agglutination of rock and molten plastic … an *in situ* type, in which plastic is adhered to rock outcrops, and a *clastic* type, in which combinations of basalt, coral, shells, and local woody debris are cemented with grains of sand in a plastic matrix," both types interpreted to result from campfire burning (Corcoran et al., 2014).

• ***pyroplastic***, n. (2019) geogenic masses of melted plastic debris found in beach environments. Similar in appearance to plastiglomerates, they are distinguished by encapsulation of plastic without agglomeration of extraneous material, leading to low bulk density and subsequent floating in seawater (Turner et al., 2019).

Chemistry & Garbology

• ***nurdle***, n. (1990s) "a very small pellet of plastic which serves as raw material in the manufacture of plastic products" (Oxford University Press, 2019a, 2019b); also known as a "pre-production pellet" or "primary microplastic".

• ***plastic confetti***, n. (2011) small, "multi-colored fragments" of plastic (Corcoran et al., 2014) formed by the degradation of larger plastic pollution. The earliest found use in this context described plastic present in the surface waters and beaches of the Pacific Ocean (Moore and Phillips, 2011).

• ***plastitrash***, n. (2000) garbage, litter, debris or other waste material made of any type of plastic material (Felger, 2000).

marine microbes and invertebrates living on millimeter-sized debris near Australia and other regions of the Southwest Pacific Ocean (Reisser et al., 2014). These epiplastic organisms create the ***plastisphere***, or communities of microorganisms persisting on floating plastics (Zettler et al., 2013). Although the term "plastisphere" was established to describe microbial communities, we suggest that the plastisphere describes both attached micro- and macro-communities, as research continues to elucidate the prevalence of macroinvertebrate communities colonizing and living on floating marine plastitrash (e.g. Goldstein et al., 2014; Gil and Pfaller, 2016; Haram et al., 2019).

Not only are micro- and macroorganisms living on plastics, but they are also ingesting them. Such phenomenon has led to a new diet categorization of ***plastivory*** and ***plastivore*** (Hohn, 2011; Allen, 2018; Irigoien, 2018). Distinct from other "-vore" suffixes for diet selection, a plastivore does not select plastics intentionally; rather, organisms, such as plankton, benthic invertebrates, birds, fish, and turtles, ingest plastic either through accidental ingestion or by mistaking their plastic prey for natural food items (e.g. Azzarello and Van Vleet, 1987; Moore and Phillips, 2011; Goldstein and Goodwin, 2013; Jang et al., 2018; Irigoien, 2018). Interestingly, the agency of organisms as "predators" of plastic is challenged by the term "***plasticized***", which points to human behavior having plasticized animals, through their ingestion of or entanglement in plastic litter (UNEP, 2016; Pravettoni, 2018a, 2018b), and nature more broadly, through the ubiquity of plastics in the environment (Eriksen, 2014). These terms lean on the original definition of plasticize – to "make plastic or mouldable, especially by the addition of a plasticizer," (Oxford University Press, 2019b). Here, however, plastic itself is the plasticizer, and harmful effects of human-originated plastic pollution are plasticizing nature, extending its meaning to an ecological and cultural context.

3.2. Geology of plastics

Linked tightly to the concept of the Anthropocene (Crutzen and Stoermer, 2000; Crutzen, 2002; Zalasiewicz et al., 2011), the ***Plasticene*** (Age of Plastics) describes the current period in geological history, beginning in the mid-20th century, with the exponential increase in global production, consumption, and disposal of plastic products

(Zalasiewicz et al., 2016). The Plasticene concept materialized from research by Corcoran et al. (2014), who suggested that the vast discarding of plastics will be observable in the fossil record, given that plastic can fuse with rock in the process of burning on beaches and rock outcrops to create ***plastiglomerates***. Recent research has highlighted further opportunities for incorporation of plastics into geologic strata with the formation of ***plasticrusts*** (Gestoso et al., 2019) and ***pyroplastics*** (Turner et al., 2019). However, the term "Plasticene" was first used outside of the scientific literature (Stager, 2011; Reed, 2015), placing the geological implications of plastic pollution within the context of society and the Anthropocene in general. Since its introduction, "The Plasticene" has been increasingly invoked in research and management literature (e.g. Mendoza et al., 2018; Gestoso et al., 2019; Tiller et al., 2019).

3.3. Chemistry and garbology of plastics

Because plastics are synthetic, man-made materials, a plethora of words (such as polyvinyl chloride, bisphenol A, and phthalates) has been created to describe the array of plastic chemical properties, compounds, and applications. These words are widely accepted and used in the manufacturing, labeling, and dissemination of plastic products. Additionally, many commonplace terms are used to describe plastic pollution in the environment (such as debris, litter, trash, refuse and garbage). With the objective to highlight lesser-known terminology, synthesizing these mainstream terms is outside the scope of our consideration here. However, a few terms warrant highlighting. ***Plastitrash***, a lesser known term for plastic pollution, is used to differentiate plastic pollution from other anthropogenic debris (Felger, 2000). In addition, we note that the phrase ***plastic confetti*** (long used in the toy and party decoration industry) is sometimes used for accumulations of colorful plastic fragments on beaches or in the ocean (e.g. Moore and Phillips, 2011; Corcoran et al., 2014). The word ***nurdle***, first used in sports (Oxford University Press, 2019a, 2019b), has been used since the 1990s both in industry and in pollution literature to refer to pre-production plastic beads (Ellison, 2007; Oxford University Press, 2019a).

4. Discussion

Lexicons expand, contract, and mature. At the start of the 21th century, and as linguists, geologists, archeologists, and anthropologists take greater note, we should expect both a proliferation and a unification of plastic-related terms. In this regard, we note, for example, the also-emerging concepts of the technosphere, technostratigraphy, and especially technofossils (Zalasiewicz et al., 2014). Technofossils were initially defined as "preserved remains of the technosphere" (Zalasiewicz et al., 2014), with the technosphere comprising all "widely distributed and interconnected technological systems on whose function modern civilization and society is based" (Haff, 2012). Dibley (2018) offers a broader view: "Motorways and cities, mine shafts and hydro dams, runways and mobile phones, drink cans and ballpoint pens, carbon emissions and nuclear radiation – everything that humans manufacture, from the city scale to the nano scale, has the potential to become a technofossil once interred through land fill or other burial processes." Within this framework, the Plasticene is one of many stratigraphic effects of modern human societies, further exemplifying the importance of standardizing our Plasticene vocabulary for inclusion in other relevant disciplines.

Not only will we leave our mark in the fossil record, but we will further influence the ecology and evolution of biological communities. An additional terminology, not yet fully standardized, seeks to describe the size or composition of plastic materials (Hartmann et al., 2019a, 2019b; Stark, 2019), both of which are known to affect ecological phenomena and processes. For example, nano- and microplastics impact microbial communities and trophic interactions across a diverse range of taxa, while larger-sized plastics (macro- and megaplastics: from straws and bottles to fishing nets) affect the dispersal, distribution, and mortality rates of macroinvertebrates, birds, marine mammals, and fishes. Despite the growing number of studies documenting such direct effects of plastics on individual animals through entanglement and ingestion, it is uncertain how these effects will translate to the population, community, and ecosystem levels and how these effects will interact with other concurrent stressors (Windsor et al., 2019).

As more research is done and terminology invented in response to growing interdisciplinary concern about plastic generation, use, and pollution, there is a natural movement toward sub-categorization of plastics research and issues into discrete disciplines or fields. However, it is important to recognize the intersectionality and globality of our plastic problem; more efforts should be made to engage in cross-boundary research and theorization. In one such promising recent effort, the geology, ecology, and garbology of plastics have been jointly harnessed to create the concept of the ***plastic cycle***, which aims to unify our conceptual understanding of plastic pollution in a single biogeochemical cycle (Bank and Hansson, 2019). With technological progress and increasing consumption of resources, both plastic-based and natural, we should anticipate the continued expansion of related vocabulary. Standardizing definitions of new terms across disciplines should be prioritized to ensure more effective communication and to minimize the potential for confusion, which can be particularly problematic for scientific reproducibility and public awareness. With this Plasticene Lexicon, we hope to encourage a unified language that reflects new insights into the means by which humans will leave a stratigraphic, chemical, and ecological footprint of our plastic existence.

Credit authorship contribution statement

Linsey E. Haram: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Project administration, Writing - original draft, Writing - review & editing. **James T. Carlton**: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Writing - original draft, Writing - review & editing. **Gregory M. Ruiz**: Conceptualization, Funding acquisition, Writing - review & editing. **Nikolai A. Maximenko**: Conceptualization, Funding acquisition, Writing - review & editing.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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