Globalizing human-technology relations

An examination of the technosphere through the concept of waste

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To the Earth,

Without which none of this

would be possible

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Summary

In the present era of increasing globalization, human influence is spreading all over the planet. Debates on the anthropocene, the epoch in which humanity has become a global force comparable to natural ones, are starting to consider the global aspect of technological relations. The concept of technosphere is gaining popularity as an approach to study the implications of these scales of technological influence. The technosphere represents an autonomous global metabolic system, a large-scale sociotechnical assemblage not subjected to human control. This thesis will investigate the merits and limits of the technosphere for thinking the global dimension of technology.

To do so, it will focus on how the technosphere frames waste. Waste offers a conceptual entry point to investigate the global scale of technological relations, in particular concerning the making and unmaking of material, social and moral boundaries. The interplay of social components and technological systems of waste disposal contributes to create, maintain and contest the boundaries that shape the ecosystems of the planet, and the lives of its inhabitants. Therefore, improving our understanding of how waste comes to be framed as such represents a crucial task to expand the scope of philosophy of technology.

The thesis will show how the systemic approach of the technosphere largely downplays the role of social components in determining the identity of waste. Waste is reduced to what hinders the metabolic functioning of the technosphere, thus revealing a more general inadequacy to account for the influence of social factors in shaping global sociotechnical processes. The role of social factors in global human-technology relations can be recovered by paying attention to the interactions of human beings and large-scale infrastructures, in order to understand how these patterns of activity influence the visibility of things, people and places.

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1. Introduction

> *It is not so much by the things that each day are manufactured, sold, bought that you can measure Leonia's opulence, but rather by the things that each day are thrown out to make room for the new. So you begin to wonder if Leonia's true passion is really, as they say, the enjoyment of new and different things, and not, instead, the joy of expelling, discarding, cleansing itself of a recurrent impurity.*
>
> (Italo Calvino, Invisible Cities, Continuous Cities 1)

When something is thrown away, one is often given the impression that it simply disappears. We try our best to move waste away, and hide it as quickly and efficiently as possible. It seems we are almost ashamed of it. However it is not difficult to realize that there is actually no "over yonder", borrowing the words of Timothy Morton, where waste can be thrown (Morton 2013). It is simply moved away, somewhere else. With the increasing globalization that characterizes our age, waste is becoming an issue that refuses to remain local.

When waste travels around the globe, it might become invisible for people in one place, while becoming highly visible for people in another part of the world. An old mobile phone discarded in Europe represents the difference between survival and starvation for someone in Nigeria (Nnorom and Osibanjo 2008). Commercial ships are broken down and recycled in Bangladesh, a rich and dangerous business to which many in the West are mostly oblivious (Gregson et al. 2010). Travelling around the world, waste changes identity and shapes the conditions of people and ecosystems. In this way waste materially connects the places it travels through, while also segmenting them along social and moral dichotomies such as clean and dirty, rich and poor.

As technology contributes to waste production and movement, thinking about the global dimension of waste becomes crucial to understand technological relations across global scales. Globalizing the study of human-technology relations is becoming an urgent matter in our increasingly globalized, and increasingly polluted, technological world. How could this task be approached through an examination of waste?

1.1 Global human-technology relations in the anthropocene

There is almost no place on earth that has not been "touched" by effects that can be traced back, in one way or another, to human activities. A widespread feeling is that humanity has reached a point of technological development that is affecting the planet on a truly global scale. With technology, a huge amount of waste is spreading all over the world, causing all sorts of problems from health hazards, to environmental degradation and global warming. This tendency has steeply increased with globalization, and human technological impact is growing at an accelerating pace to affect larger and larger scales, closing distances between faraway places. In this way, human technological activities are becoming a major factor in the future evolution of planet Earth. Geologists, therefore, have proposed to rename the present geological epoch after the pervasive effects of such alleged human technological exceptionalism. The era in which humanity has become a geological force is called *anthropocene* (Crutzen and Stoermer 2000; Crutzen 2002).

In general, the concept of anthropocene describes the fact that human activities have grown to scales large enough to rival natural phenomena, leading to the necessity of rethinking how we view and interact with the natural world and the place of human beings in it (Malhi 2017). As such, it

brings to the fore many crucial challenges for the contemporary globalized technological society. Making sense of the global dimension acquired by humanity, the sheer planetary scale of its technological influence, appears as a fundamental aspect disclosed by the concept of anthropocene.

On a terminological note, throughout this work the term "anthropocene" will be mainly used without capitalizing it. This is in order to give the term a less charged connotation (Ellis et al. 2016). The lower-case adoption lets the term work more flexibly as an informal way to refer to a contemporary cultural, social and scientific movement that brings to the fore the causes of contemporary global issues, and the role and composition of humanity in it. I will employ the capitalized form of "Anthropocene" to refer to the proposed formal geological epoch following the Holocene in the context of natural sciences, and to the underlying visions of technology and society, which will be referred to as the Anthropocene narrative.

American political theorist Langdon Winner, albeit disagreeing with the concept itself, remarked the need for thinking about the Earth, the very substrate that supports, materially and ontologically, technological practices, and the philosophical discourse on technology (Winner 2013). For philosophers of technology the anthropocene constitutes an invitation to expand their thinking to the broader, global scales of technological relations, an aspect which has yet to gain the attention it deserves from most contemporary approaches. As historian of technology Gabrielle Hecht (2018) calls it, the anthropocene is fundamentally a *scalar project*. Engaging with it requires to expand the philosopher's view of human-technology relations to larger scales, appropriate for the implicated dimension of global technological effects, which might very well require a "terrestrial turn" in philosophy of technology (Lemmens, Blok, and Zwier 2017). This requires attention to be paid to the co-evolution of society and technology through the large-scale interactions that co-shape the development of both (Donges et al. 2017). By global human-technology relations it is meant interactions between social and technical systems that can occur either at the individual or at the social level, but whose effects spread on a large-scale, as in the case of interactions between human beings and technological infrastructures. Issues of collective agency towards technology, and issues of individual, technologically-mediated large-scale relations to faraway places, are thus brought together into the picture. This thesis will engage with the challenge of getting a better grasp of global human-technology relations by starting from an examination of the concept of *technosphere*.

1.2 The technosphere paradigm

The concept of technosphere is gaining a certain prominence in the anthropocene debate as a framework to conceptualize large-scale relations between technology, human beings, and the environment. Framing technology as a "sphere" seems to suggest both a layer wrapped around the planet and the possibility to study it as a single object that can be described as a whole. The idea of technosphere approaches the study of technology from a global perspective, trying to capture its large-scale dynamics.

The term was introduced by geologist Peter Haff (2014a), who coined it to refer to the large-scale networks of technologies that allow rapid global transportation and communication, including the bureaucratic systems necessary for their coordination. It is being studied both in scientific disciplines as a geological paradigm[1] to investigate the global dynamics of technological networks (Zalasiewicz et al. 2017), as well as in the humanities as a term referring to the global dimension of technology in general (Lemmens, Blok, and Zwier 2017). Technology, seen in this way from an

[1] Other geological paradigms include the lithosphere, the biosphere, the hydrosphere and the atmosphere.

external, geological perspective, assumes the character of an autonomously developing metabolic system, not subjected to direct human control. Human beings are simply one part of this worldwide, earth-shaping assemblage.

Given the popularity of Haff's proposal in current debates on the anthropocene, the technosphere framework, as he proposes it, offers a natural starting point to begin an analysis of how philosophers of technology could approach the global dimension of technology. The way in which Haff conceives the technosphere raises fundamental issues about the roles technologies play in mediating the relations between different scales and places around the planet, and about the role of politics in directing this world-wide sociotechnical assemblage. Haff's main provocation involves a consideration of technological networks as belonging to a global autonomous system that is not subjected to human control, but rather, evolves according to its own autonomous dynamics.

The thesis of technology's autonomous development, a stance defended by so-called "classical" philosophy of technology, has been challenged by empirical approaches to technology at least during the last thirty years of philosophy of technology, and Science and Technology Studies (STS). These studies highlighted the fundamentally open-ended and co-constructed character of human-technology relations, where social factors play a key role in shaping the outcomes of technological developments (Verbeek 2005). Treating technology as autonomous, conversely, has clear consequences for how the technosphere frames the role of human individuals and social groups in the broader planetary context. The perspective of the technosphere, while priding itself on doing away with anthropocentrism, tends to eliminate the agency of the individual, and disregards the power of politics and social groups to influence large-scale technological developments.

These are aspects that can be scarcely downplayed, as this thesis will show, when trying to understand how the global scale of the anthropocene is reshaping our understanding of technological relations. These issues are reflected by the way in which Haff treats the concept of waste, which will offer a fruitful entry point to analyze merits and problems of the technosphere framework.

1.3 Waste and boundaries in a globalized technological world

Waste can offer a useful lens to study how the technosphere conceives the relations between human beings and technologies on a global scale. How can an examination of the concept of waste address the shortcomings of the concept of technosphere as a way to understand global human-technology relations? This is the main research question that this thesis will investigate.

First of all, it is necessary to clarify how waste can be a conceptual entry point to think about global human-technology relations. Waste travels through the broad networks of infrastructural relations that link different groups of human beings together, and to the rest of the biosphere. Along these paths the interplay between waste materials and human beings, social components and technological infrastructures of waste disposal, creates and challenges boundaries that influence the conditions of people, things, and places. The idea of waste is in fact an inherently normative concept, the identification of which tends to draw and materially enact distinctions between waste and non-waste, the dirty and the clean etc. Waste enables the recovery of the role of social actors, as its normative character provides a direct link to questions about who frames a certain thing as waste, and why. By adopting the theory of social systems proposed by German philosopher and sociologist Niklas Luhmann (1927-1988), waste can be seen as the constitutive and relational product of social and material processes of boundary making. When we investigate how waste is

represented, "we are asking which side of key dichotomies waste has been identified with […] and with what consequences" (Gille 2007, 34). By examining how waste comes to be identified as such, it is possible to understand how boundaries are likely to be drawn, and with what effects. Understanding the formation, the disruption and the effects of such boundaries, in turn, offers a key way to reveal the roles of technologies in mediating large-scale relations between different places, shaping the planet and the lives of its inhabitants (Luhmann 1982).

Therefore, the aim of this thesis is to evaluate the concept of technosphere as a framework to think about global human-technology relations, and sketch a way to address its shortcomings. This will be achieved by studying the way in which waste is framed by Haff within the technosphere and by offering a revised account of waste that addresses the limitations of the technosphere to account for the social and technical complexity of human-technology relations at the global scale. Accordingly, what this thesis aims at is revealing the conceptual assumptions behind the way in which Haff's technosphere frames large-scale human-technology relations through the way in which it conceptualizes waste. What this will hopefully point to is way to gain a more critical understanding of global technological relations, in particular concerning the technological, material, social and political factors that influence how waste is identified. This will be done through an active engagement with human and social disciplines such as philosophy of technology and discard studies. In this way this thesis launches an initial foray to expand philosophy of technology into the global scales of the anthropocene.

Why is waste, however, such an interesting topic to reveal how the technosphere describes global human-technology relations? Much of what was said above could be seen through many different lenses, such as production, which nowadays is as global as waste. There are two main reasons behind this.

The first of which is concerned with the technosphere. Using waste as an entry point to examine the technosphere is particularly interesting because waste represents a central challenge for the future existence of the technosphere. According to Haff, whether the technosphere will endure as a geological paradigm will ultimately depend on its ability to recycle its own waste products (Haff 2014a, 305). This capacity is characteristic of all other geospheres, where materials undergo several processes of transformation, but they still remain within what can be ultimately considered a closed cycle. Since the technosphere has not yet developed the capacity to recycle all of its waste products, its status as a geological paradigm is still provisional. Understanding how waste is identified as waste within the technosphere is thus not only revealing about the global networks of sociotechnical relations that influence the boundary-making processes that define something as waste. It is also crucial in order to understand whether the technosphere framework can be useful in guiding us in the contemporary challenges of sustainability, pollution reduction, and waste management.

The second reason is concerned with the anthropocene. Waste bears a fundamental link to the changing relations between human beings and the planet emphasized by the concept of anthropocene. As mentioned above, the anthropocene is concerned with the traces left by human technological activity, which are becoming so large as to rival natural forces. The waste produced by human activities is accumulating at such a fast rate that is putting in serious question the ability of nature to replenish the resources we consume. In a very material sense, the scientific evidence of the anthropocene as a new geological epoch in which humanity is able to influence global natural cycles (Crutzen 2002), is constituted by the waste products of large-scale technological activities:

anthropogenic CO_2, nuclear waste, "plastiglomerates"[2] and other "technofossils" (Zalasiewicz et al. 2014). The anthropocene can therefore be understood as signifying also an *apotheosis of waste* (Hecht 2018). More concretely, the anthropocene is composed by the residual waste of the technosphere, that goes on to form geological layers that bear clear traces of human activities.

Employing waste as a vehicle to examine global human-technology relations in the anthropocene becomes also a way to explore how the relationship of humanity to the planet changes with its increasing power to affect it, and the role of large-scale sociotechnical networks in this change. It is an operation that raises political but also anthropological questions about global human-technology relations.

Given the variety of words available to talk about waste, another terminological clarification is needed. Waste is not the best word to describe the concept of waste that will be discussed throughout this thesis, but it was opted for to improve readability. The common idea of waste, in fact, seems to bear nuances of guilt and remorse, especially in connection to its verbal form. Something is wasted if the value that it *could have (had)* is lost. That is how we talk about wasted time and wasted resources, as things whose value has been lost, or about a wasteland, a place from which no value can be extracted. In this sense, the idea of "waste" can be closely associated with ideas of efficiency, productivity, exploitation, and zero-waste: an absolute hate for things that "go to waste", that do not produce value.[3] A better word choice to indicate what a constitutive and relational notion of waste means would be "refuse", which will be used sparingly. Refuse indicates the material that is rejected and discarded, the unwanted. Rejection is a much more resolute attitude than the feeling that something has been wasted. Who regrets wasting still longs for value. What is rejected can be resolutely refused, but thereby lies the possibility to establish a form of value. Waste as constitutive refuse is, paradoxically, both what is rejected and also what one cannot but feel awkwardly grateful for, because without its rejection the production of value would not have been possible. The importance of this for the thesis' goal will become clearer in chapter 3.

1.4 Addressing the challenge

To recap, understanding how waste is identified as such within the technosphere is a question of primary importance to understand how the technosphere frames global relations between technologies and human beings – in particular the relations that produce such identifications of waste through processes of boundary making – in their social, political and material aspects. The importance of using waste to this aim lies in its inherent normative character, that is helpful in addressing the disregard of the technosphere for social agency, in the role that waste plays for the future of the technosphere itself, and in its connection to the anthropocene as an epoch that redefines the place of humanity in the world.

The aim of this thesis is not to produce an ethical evaluation of the global impacts of technology on human beings and non-human nature. Nor is it to somehow "solve" the global problem caused by human waste and pollution. The thesis will show how the technosphere, while rightly highlighting that technology is not fully under the control of human beings, offers a limited understanding of the influence of social actors in shaping global sociotechnical processes. This will be revealed by attending to the complexity of waste, which shows how the technosphere framework

[2] Plastiglomerates are stones formed by natural debris held together by solidified molten plastic.
[3] It is thus not surprising that waste has been used to talk about the type of refuse that defines modernity (Cooper 2010), in contraposition to Douglas' idea of dirt.

downplays the role of social components in determining waste identity and of technological developments more in general. Getting a better grasp of the global dimension involved in human-technology relations is necessary if we are to envision alternative, more globally and ecologically aware modes in which these relations can take place.

In order to understand the way in which the technosphere conceptualizes global human-technology relations, chapter 2 will be devoted to the analysis of Haff's framework. First the main lines of the debate on the anthropocene will be reconstructed, in order to situate Haff's proposal within this line of research. Next the concept of technosphere will be analyzed in detail in order to gain a complete picture of how it conceives human-technology relations at the global scale. The way in which it conceptualizes waste will then be examined to clarify the stakes at play in the systemic approach of the technosphere for understanding the global dimension of human-technology relations. The geological perspective of the technosphere will appear problematic in its tendency to treat the relations between social actors and large-scale technological systems asymmetrically, attributing much more agency and influence to the latter. This will lead to conclude that the technosphere framework downplays the influence of social actors in shaping technological developments. Under Haff's paradigm, global material and political inequalities (in wealth, pollution etc.) are depoliticized through the autonomous development of the technosphere, indirectly legitimizing a top-down technocratic approach and hindering the possibility to envision alternative ways of dealing with how technology impacts humans and non-humans.

Chapter 3 is devoted to a re-examination of a concept of waste that recovers the role of social and political factors in global sociotechnical developments, in order to address the shortcomings of the technosphere as a model to study global human-technology relations. This is possible by arguing for a constitutive, relational and dynamic concept of waste that pays attention to how the category of waste is shaped by complex interactions between society and technological infrastructures. The structural approach to waste by social anthropologist Mary Douglas, and the theory of social systems by Niklas Luhmann will be integrated by the concrete case studies on waste disposal infrastructures offered by discard studies. By studying global human-technology relations through the open-ended processes of boundary making that identify waste as a dynamic category, it becomes possible to criticize the simplifications operated by asymmetrically assigning all the power of influence to the large-scale technological dynamics of the technosphere. In this way, a potential approach to the study of the global scale of human-technology relations will be suggested. In the conclusion, the consequences of approaching global human-technology relations through a relational and dynamic concept of waste will be further analyzed.

2. The technosphere

Many of the critiques moved to the concept of anthropocene, as we will see below, accuse the term of universalizing humanity in an indistinct mass which would be collectively responsible for the ecological and social disasters of the current epoch (Haraway 2016; Malhi 2017). The technosphere encounters a similar risk to naturalize and depoliticize existing geopolitical issues. By viewing technology as an autonomous system that develops according to its internal laws that subjugate human beings and nature, existing inequalities across the globe are attributed to causes that lie essentially outside human ability to shape them, with the risk of removing any historical responsibility. As a consequence, the perspective of the technosphere reveals a major disregard for the power of social and political action to influence large-scale technological developments. This is clearly illustrated by the reduction of the concept of waste to what hinders the metabolism of the technosphere. For these reasons, it is still an open question how helpful the concept of technosphere is in order to understand global human-technology relations.

The question this chapter sets itself to answer, therefore, is how global human-technology relations are framed within Haff's account of the technosphere, how its treatment of waste is symptomatic of this, and why it is unsatisfactory. This is the first step to understand how an examination of the concept of waste can be helpful to address the shortcomings of the technosphere to think about the global dimension of technology.

Therefore, in order to understand how the technosphere accounts for the global dimension of human-technology relations, the aim of this chapter is to reconstruct the context of development and the theoretical details of the concept of technosphere, and to focus on how waste is framed within it. This will first require an introduction to the larger debate on the anthropocene (§2.1), and to situate the technosphere within the scientific side of such debate (§2.2), as some of the characteristics of the model can already be found in previous discussions. Subsequently the focus will move to how Peter Haff introduced the idea of technosphere, its main characteristics, and its relation to the anthropocene (§2.3). The stage will thus be set to engage with Haff's conceptualization of technological (§2.4) and political relations (§2.5), in order to grasp how the technosphere model describes global human-technology relations. The chapter will then zero in on how the concept of waste is framed within the technosphere (§2.6), showing how it follows from the characteristics of Haff's framework. A critical evaluation of such an understanding of waste, and the import of making sense of waste for understanding global human-technology relations beyond Haff's limitations, will be the aim of the following chapter.

2.1 The anthropocene debate

The majority of contemporary discussions on the technosphere are embedded within the anthropocene debate, from which they inherit their liveliness, due to the theoretically and politically loaded terms employed. As we will see, the recent popularization of the technosphere comes from an original formulation in the vocabulary of Earth system sciences, similarly to the idea of "Anthropocene" as a new formal geological epoch. However, both the concepts of technosphere and of anthropocene bear a broader significance that makes them interesting also for social and human sciences dealing with the study of technology, as they raise intense discussions about the social and political relations that shape the large-scale dynamics of technological development. Taking seriously the implications of the technosphere, in fact, makes us reflect about the role of

large-scale technological systems, in mediating the relations between human beings and the global issues of the anthropocene (Haff 2014b, 127). It is crucial to start our path through these issues by giving a clear picture of the broader significance of the anthropocene debate, some traits of which reveal the influences that led Haff to conceive the technosphere.

The term "Anthropocene" made its appearance in a short 2000 article by Dutch Nobel prize winner atmospheric chemist Paul Crutzen and American geobiologist Eugene Stoermer. The scientists illustrated through a variety of geophysical data concerning natural cycles, resource consumption, and loss of biodiversity, how human technological influence on the whole planet had gradually increased during the Holocene, surpassing the scale of natural processes. The history of human culture and technology had become global natural history. Therefore, they proposed to name the new human-dominated geological epoch "Anthropocene" in order to "emphasize the central role of mankind in geology and ecology" (Crutzen and Stoermer 2000, 17). Starting from a subsequent short article by Crutzen in *Nature* (2002), the term quickly caught the attention of both natural and social scientists, slowly spreading into multiple academic disciplines and public debates (Lorimer 2017; Malhi 2017).

The idea of human impact on nature is certainly not new. Crutzen and Stoermer individuated the idea of the growing scale of anthropogenic impact on the environment already in the works of the Italian geologist Antonio Stoppani (1824-1891), the Russian geochemist and cosmist philosopher Vladimir Vernadksy (1863-1945), and the French Jesuit philosopher Pierre Teilhard de Chardin (1881-1955) (Crutzen and Stoermer 2000, 17). Stoppani, a Catholic abbot, described in his 1873 *Corso di Geologia* the arrival of man as a new "telluric force", whose God-bestowed strength and universality is comparable to that of other global forces, heralding the "Anthropozoic era" (Turpin and Federighi 2012, 36). Stoppani anticipated that the power of human beings to modify their environment will transform future geology into a narration of human intelligence. His emphasis on human exceptionalism makes him an obvious choice for Crutzen as a precursor of the Anthropocene.

Vernadsky and de Chardin met in Paris in the 1920's and had frequent discussions with French philosophers Edouard Le Roy and Henri Bergson. During this period, they elaborated the concept of *noösphere*, from the Greek word *nous*, mind, to refer to a new stage of evolution of the world after the formation of the earth, the *geosphere*, and the emergence of life, the *biosphere*, that displays a new factor in play, the human mind (Samson and Pitt 1999). According to Australian author Clive Hamilton and French philosopher Jacques Grinevald (2015, 66), the noösphere can be taken to broadly indicate the product of a process of Lamarckian evolution that generated a "thinking layer" encompassing the biosphere, and representing a teleological destination of humanity's power over the other spheres. In spite of the existence of remarkable differences between Vernadsky's more naturalistic interpretation of the noösphere and de Chardin's more religious one, Crutzen and Stoermer take it to generally celebrate "[…] the world of thought, to mark the growing role played by mankind's brainpower and technological talents in shaping its own future and environment" (2000, 17).

When the general concept of technosphere is understood within this evolutionary line, it can be taken to represent a subsequent evolution, or specification, of the noösphere, that developed the capacity to exert more and more influence on the world through technology. In this path of evolution, life became conscious through human beings, and then developed technological proficiency. The anthropocene, as the epoch of human technological exceptionalism, would thus be defined by the emergence of the technological layer of the technosphere. As we will see, this

interpretation aligns with Haff's, and it is important to keep it in mind. It could be observed, in fact, that in this evolutionary narrative, the noösphere seems to represent both the emergence of the human mind, and the emergence of science as the prerequisite to develop technology. Science appears to be the natural consequence, and to almost coincide with, the development of consciousness. On the other hand, there does not seem to be any evident sign that accounts for the role of human cognition in the evolution of social behavior (Bjorklund, Causey, and Periss 2010). In this sense, the political nature of human beings seems to be disregarded in favor of their scientific and technical abilities to master nature. However, this is by no means the only way to understand the nature of the technosphere within the anthropocene debate.

Whether the proposals by Stoppani, Vernadsky, and de Chardin are prescient of the coming of the anthropocene is, in fact, open to debate. Hamilton and Grinevald make a compelling case that illustrates how the idea of "Anthropocene", in the geological sense, hinges upon an understanding of planet Earth as a complex and interrelated system that was scientifically developed only during the 1970s-80s (2015), an approach that we will see in more detail in the next section. They take the anthropocene to represent an evolutionary rupture with previous metaphysical visions of linear development from geosphere to biosphere to noösphere. The question of the status of the anthropocene as marking an exceptional development or a "natural" continuation of human mastery of nature is precisely one of the pivotal points that the scientific, cultural, and geopolitical debates are centered on.

Because of the implications of the concept of anthropocene for thinking about the place and role of human beings in the broader context of the planet, this concept is at the center of the current cultural *zeitgeist*, and a lot of ink is being spilled to determine whether it represents a moment of rupture or continuity, of doom or possibility. Naming an entire epoch after the human species seems to celebrate the apotheosis of the power of humanity to alter nature, which started during antiquity and gained a dramatic increase after the Industrial Revolution. Therefore, some take this historical growth of technological power to encourage even more ambitious proposals of planet management through geo-engineering projects, perhaps leading to the ultimate transformation of the entire Earth into a human-controlled technological artifact (Asafu-Adjaye et al. 2015). Others instead see the dangers and the responsibility that such powers entail for the future existence of humanity and propose a variety of different responses from the more technocratic (Crutzen and Stoermer 2000) to the radically subversive (Haraway 2016). The uncontrolled increase of human impact on the environment, in fact, emphasizes also the negative consequences of such a widespread influence on natural ecosystems. Intensive technological activities lead to dangers of environmental degradation and resource depletion, causing global pollution, increased extinction rates, unprecedented global warming, and growing weather instability. Additionally, and albeit being in large part the responsibility of the more industrialized populations, such interference with global natural cycles is unequally impacting different human populations around the world, thus raising issues of global justice and planetary limits.

For these reasons, the idea of anthropocene remains harshly controversial. Earth system scientists are looking for evidence to propose it as a formal geological epoch, as we will see in the next section (Steffen et al. 2011; Zalasiewicz et al. 2015). Posthumanity and postcolonial scholars protest against the anthropocentrism and Western bias implicit in the idea of anthropocene as encompassing all of humanity, rushing to find more suitable names that more accurately identify its causes in an attempt to re-politicize the scientific approaches to global problems of science and technology (Haraway 2016; Moore 2016). Some find it at least a useful concept for inspiring

different approaches to the problem it raises, while others find it useless at best, and confusing at worst (Winner 2017).

As we can see, the systemic approach of natural science to the anthropocene raises a lot of political discussion about the role of specific human groups in bringing about the planetary impacts we are witnessing. From the first attempts to understand the global dimension of technology, a tendency to disregard political relations is already visible, a problem that, as we have seen, forms the core of many discussions within the anthropocene debate. This aspect is particularly visible in the scientific side of the debate, to which we now turn.

2.2 The Anthropocene narrative

In order to understand the original background of the concept of technosphere, we need to briefly delve into the scientific discussions of the "Anthropocene", here capitalized to refer to a formal geological epoch. The technosphere was in fact originally formulated within this debate, part of an Anthropocene narrative from which it inherited a certain way of treating human-technology relations that disregards the influence of social and political factors in technological processes, and opts for a top-down approach to sociotechnical management.

From the perspective of Earth system sciences, the Anthropocene is being discussed as a formal proposal to individuate a new geological epoch following the Holocene, which started about 11.700 years ago. To this aim the Working Group on the Anthropocene (WGA) has been established in 2009, largely comprised by geoscientists such as Zalasiewicz, Crutzen, Haff, Ellis, Steffen; and only one environmental historian, McNeill, and one philosopher, Grinevald (Ellis et al. 2016).

Various dates have been proposed as the starting point of the Anthropocene epoch (Malhi 2017). The initial proposal placed it at the beginning of the Industrial Revolution in the late 18th century. The study of the variation of the atmosphere's composition through polar ice cores revealed an increase of the atmospheric concentration of carbon dioxide and methane around the time of James Watt's invention of the steam engine in 1784 (Steffen et al. 2011). The proposal for an "early Anthropocene", situated at the beginning of human agriculture around 10.000 years ago, hinges upon similar considerations concerning anthropogenic atmospheric influence on global temperatures (Ruddiman 2013). However, the period of economic boom that followed World War II, known as the "Great Acceleration" was later argued to be more "stratigraphically optimal" (Zalasiewicz et al. 2015). Its boundary, placed at the detonation of the first nuclear bomb during the Trinity Test on July 16th 1945 in Alamogordo, New Mexico, signals the starting point of a global diffusion of artificial radionuclides, and demarcates an age of massive global industrialization and economic interconnection.

The geophysical understanding of the Anthropocene that can be gathered from these discussions emphasizes the scale of human impact on the Earth system, and thus the exceptionalism of the present age. According to Earth system scientists the global scale assumed by anthropogenic effects demands a suitably global response. Crutzen already called for "scientists and engineers to guide society towards environmentally sustainable management", which will require "appropriate human behaviour at all scales, and may well involve internationally accepted, large-scale geo-engineering projects, for instance to 'optimize' climate" (2002, 23).

A techno-optimist response to such a situation came from the so-called ecomodernists, who see the "decoupling" of economic growth and human development from environmental impacts, enabled by technological progress, as the key to realize a "good Anthropocene" (Asafu-Adjaye et

al. 2015). While Crutzen and other Earth system scientists see science-guided planetary management as the only solution to the exceptional crisis the Earth ecosystem is going through, eco-modernists advocate such a solution on the basis of the positive (positivist) affirmation of the potential of science and technology to resolve all the problems related to pollution and resource scarcity. Both however can be seen as proposing an essentially managerial approach to survive in the anthropocene (J. Zwier and Blok 2017).

In this way many scientific approaches to the anthropocene, or what we could call the Anthropocene narrative, display a lack of belief in the effectiveness of spontaneous and local social and political answers to address global ecological problems. A solution is possible only through global top-down organization and coordination, the only way to manage the global scale of technology in the anthropocene. This fact seems to point to a paradoxical tension that lies in the very concept of anthropocene within the Anthropocene narrative, that at the same time celebrates humanity, but downplays the power of influence of human beings on large-scale dynamics. The anthropocene thus becomes the epoch of maximum power of humanity, and of the almost complete lack of control by individuals on this power.

These aspects are influenced by, and have an influence on, how global human-technology relations are approached, especially concerning the interactions between technological and sociopolitical factors at different scales, as we will see further below. Technology seems in fact to be reduced to a mere instrument that obeys human desires, a conception known as technological instrumentalism. If the ecological disasters of the Anthropocene have been caused by unforeseen effects of the technologies we have made, then we can build better technologies to lessen our impact on the environment, or to re-engineer it outright. Skepticism about bottom-up political action and technological instrumentalism thus appear as the defining features of the Anthropocene narrative, which seems to endorse, more or less directly, a technocratic approach. The technosphere proposal, as we will see in the next section, displays some of these tendencies when treating global human-technology relations, meanwhile, for certain aspects, turning this vision upside down.

2.3 The technosphere as the defining system of the anthropocene

With this section we start our examination of the technosphere as a theory to study the global scale of human-technology relations. The aim is to show how the technosphere is tightly connected to the idea of anthropocene, as the epoch defined by the planetary technological influence of humanity, and to individuate the crucial points to be examined next to flesh out the way in which the technosphere treats human-technology relations at the global scale. The technosphere marks in fact the newly emerged system that is responsible for the growth of planetary impacts that define the anthropocene. This connection, however, is complicated by the way in which the technosphere frames technology on the global scale as an autonomous metabolic force, thus displacing the anthropocentrism and technological instrumentalism of the Anthropocene's supporters, while at the same time exacerbating the downplaying of social and political influences on technological processes that we already found above. A discussion of the technosphere's description of the autonomy of technology will be fleshed out in more detail in §2.4, while its consequences for social and political relations to global technology will be discussed more in depth in §2.5.

The available publications on the topic already provide a clear display of the relations between the technosphere and the anthropocene. One of the three most prominent journals on the anthropocene, *Anthropocene Review* (SAGE Publishing), published a special issue titled

"Perspectives on the technosphere" in 2017. The same year a "Special Issue on the Anthropocene" of the journal *Techné: Research in Philosophy and Technology*, describes the technosphere as the "planetary technical system", and emphasizes the need for "fundamentally reframing the technosphere […] from a largely destructive and exploitative into a more constructive and care-taking part of the Earth System" (Lemmens, Blok, and Zwier 2017). The *Haus der Kulturen der Welt* (HKW) in Berlin has been organizing the *Technosphere* (2015-19) research project, in collaboration with the Max Planck Institute for the History of Science. In order to grapple with what is perceived as a "conceptual innovation as well as a political challenge" (Klingan et al. 2017), the project organizes a series of performances, conferences and seminars with the international collaboration of many natural and social scientists, thinkers from the humanities and the arts. Part of the project has been the 2016 "Anthropocene Campus: The Technosphere Issue", which brought together this different expertise to investigate different aspects of the concept.

The connection between technosphere and anthropocene becomes central in the main account that has been proposed of the former. The concept of technosphere was formally introduced within the geological debate on the Anthropocene by American geologist Peter Haff. However, given the popularity of both affixes forming its name, "technosphere" is, unsurprisingly, not a completely new word. It has been around at least since the 1960's (Milsum 1968), assuming sometimes very different connotations.[4] In short, the technosphere, according to Haff, indicates a "global apparatus" that finds and extracts energy sources from the environment, and employs them to sustain itself and support its parts, including human beings (Haff 2014b, 129). By briefly delving into its characteristics as a geological paradigm, we can find the main connection to the anthropocene.

In his first (2014a) paper entirely dedicated to the concept, Haff offers five criteria that the technosphere ought to satisfy in order for it to be considered an emergent geological paradigm, comparable to existing ones such as the atmosphere and the hydrosphere. These are: global extent, appropriation of resources, conservative nature, recycling of mass resources and autonomy. The first two are immediately visible from the first and rather lengthy definition Haff gives of the technosphere:

> the set of large-scale networked technologies that underlie and make possible rapid extraction from the Earth of large quantities of free energy and subsequent power generation, long-distance, nearly instantaneous communication, rapid long-distance energy and mass transport, the existence and operation of modern governmental and other bureaucracies, high-intensity industrial and manufacturing operations including regional, continental and global distribution of food and other goods, and a myriad additional 'artificial' or 'non-natural' processes (Haff 2014a, 301).

The technosphere is thus, before everything else, a world-wide network of large-scale technologies. When looked at from the perspective of Earth system science, technology becomes a phenomenon that must be investigated at the macro-scale level of large technological systems. Among the primary constituents of the technosphere we find therefore all those infrastructures that enable mass global transportation of materials and people, and communication infrastructures. In the global extension of its effects, the technosphere thus resembles traditional geological paradigms.

[4] A similar concept was developed in the 1970's with the name of "industriosphere" to study its interactions with the other natural spheres (Hall 1975). The term has also been employed earlier by the philosopher of technology Friedrich Rapp (1981) and by the landscape ecologist Zev Naveh (1982).

The second trait, the appropriation of resources, can be glimpsed from the functional organization of this global technological assemblage. The technosphere makes possible the extraction of large quantities of energy from the environment, fossil fuels in particular (Haff 2014a, 303). With this energy it enables mass production and transportation through large-scale technological infrastructures; it supports the bureaucratic systems necessary for their management; and makes rapid global communication and coordination possible. The technosphere is thus a "dynamic system", a system which displays metabolic dynamics of energy appropriation and resource consumption in order to sustain itself.

The conservative nature of geological paradigms, the third trait, derives from the prerequisite of their stability. A global geological paradigm, in order to be recognized as such rather than as a temporary phase, needs to display a certain stability through time. A newly emerged system tends to be stable through time if it ensures the preservation of the conditions that enabled its arising, and are conducive to its maintenance. For example the emergence of the biosphere radically modified the soil, the atmosphere and the hydrosphere, which continued to exist in modified ways and kept supporting the existence of living organisms. The technosphere looks like an exception in this regard, as it is testified by the increasing destruction of the environmental conditions that permitted its emergence. If the rate of degradation will not stop, it might threaten the future existence of the technosphere (Haff 2014a, 304).

The prerequisite for the conservative aspect of geological paradigms is their ability to recycle mass resources, the fourth trait. The technosphere, however, is presently unable to recycle the resources it consumes. As a metabolic system functioning in the close environment of our planet, the technosphere must be able to completely recycle its own waste stream if it is to endure as a geological paradigm. The biosphere virtually recycles all the materials it employs thanks to subsystems of the ecological networks that degrade dead organism into basic components that can then support new life. The absence of effective recycling mechanism in the technosphere, instead, produces an accumulation of waste materials that, in the long run, can hinder the technosphere's functioning. The depletion of fossil fuels and metal resources, and the consequences of global warming for human health, pose actual risks to the continued activity of the technosphere.

Lastly, Haff claims that the technosphere is an autonomous system, the fifth trait. This means that its dynamics are not subjected to direct human control. Contrary to the illusion of control afforded to humans by small-scale technical artifacts, large-scale technological systems are fundamentally under no one's control. While I can unplug my fridge if I so will, I have virtually no control over the power grid that the fridge's operation is dependent upon. Since humans are still necessary to set up large technical systems and resolve glitches, Haff uses the term "quasi-autonomous" (2014a, 306). Nonetheless he recognizes a tendency to develop more and more autonomous systems, since contemporary human societies depend so much on large-scale technological systems. For example, the power grid is equipped with feedback-loop "defense mechanisms" that ensure its continued functioning in case of interruptions and problems, making it thus effectively autonomous (*ibid.*).

To sum up, according to Haff the technosphere currently satisfies at least three of five features characteristic of earlier natural paradigms: it has global extension, it appropriates natural resources, and it is fundamentally autonomous. Differently from older paradigms however, the technosphere currently displays an alarming anti-conservative tendency, as it is unable to effectively recycle the waste stream it produces. This destabilizing factor is what sets the technosphere apart from established geological paradigms. According to its supporters in fact, one of the reasons to

introduce the Anthropocene after the climatically stable Holocene, is precisely to mark the anthropogenic alteration of the conditions that permitted the evolution of human populations and technology in the first place. Consequently, it is not surprising that Haff calls the technosphere "a global system whose operation underpins the Anthropocene" (2014b, 127), and "the defining system of the Anthropocene" (Haff 2017, 103). In other words, the emergence of the technosphere *sensu* Haff can be considered both the cause and the defining structure of the anthropocene.[5]

As we anticipated at the beginning of the section, however, it would be misleading to automatically assume that this conception of the technosphere falls so neatly within the Anthropocene narrative. The latter sees humanity's recently acquired geological agency as enabled by its mastery of technological means, through which it realizes its goals. The *Anthropo*cene is the epoch of humanity. Haff dismisses this idea, through the words of philosopher Erich Hörl, as the "Anthropocene illusion" (Haff 2014c).[6] The technosphere, in fact, harbors different consequences for the place of human agency within the global dynamics of technology. The *techno*sphere, observing technology from an external, geological perspective, assumes the character of an autonomously developing metabolic system, not subjected to direct human control. Human beings are simply one component of this worldwide assemblage. The next two sections, therefore, will analyze the two sides of this way of treating global human-technology relations. First we will focus on how the technosphere describes the autonomy of technology, in connection to the discussions on the topic found in philosophy of technology. Subsequently the political side of global human-technology relations will be discussed.

2.4 The technosphere's philosophy of technology

Against the Anthropocene narrative, the technosphere seems to offer a rebuke to its naïve instrumentalist view towards technology, the stance according to which technologies are mere instruments that simply obey human orders and whose effects are entirely determined by human goals. The study of global technological effects decenters our view from human desires to the large-scale dynamics of technology development. There is the danger, however, that such a reasonable critique of the Anthropocene narrative becomes an endorsement of technological determinism, the vision according to which technology is an autonomous force independent of human intentions, which shapes and determines its own development. Haff, in fact, does refer to such predecessors as Jacques Ellul and Langdon Winner, William Brian Arthur and Kevin Kelly. Their works, he says, "go a long way toward disabusing the notion that humans operate as independent agents in the modern technological world" (Haff 2014b, 127). This is a very heterogeneous group of thinkers, who endorsed very different visions of technology and technological development, from a more strictly teleological determinism to more a modest proposal for the existence of subject-independent technological dynamics.

In contemporary philosophical and social studies of technology, the idea of technology as an autonomous force, also very common within so-called "classical" philosophy of technology, has been fiercely criticized through empirical case studies that illustrate how both technologies and

[5] To avoid confusion, the reason for employing here the lowercase form of anthropocene should be pointed out. The lowercase form, being broader in meaning than the uppercase one, here refers to the fact that the technosphere marks both the Anthropocene as the geological epoch approached by the sciences through the Anthropocene narrative, but also the anthropocene more in general as the concept raising the issues of the global impact of technology and humanity.

[6] For a more thorough discussion of the Anthropocene illusion see Hörl's contributions in Behnke et al. (2015) and Hörl (2017).

social actors play key roles in shaping technological development. This is illustrated by the work done in Social Construction of Technology, Actor-Network theory, and postphenomenology (Verbeek 2005, 101). Haff's wording seems cautious enough to warrant a charitable reading. The impression is that his main goal is to argue against the idea of human agents as being completely free and uninfluenced by technologies, rather than endorsing a form of technological determinism. As far as the non-neutrality of technology is concerned, Haff's contention seems comparable to the intentions of postphenomenology.

Postphenomenology is a contemporary approach that, within philosophy of technology, argues for the fact that technologies are not neutral, but that they actively mediate the way in which someone experiences the world, and acts in it (Verbeek 2005). A major difference however lies in the source of this non-neutrality. According to postphenomenology's attention to the subject's experience, it lies in the fact that technologies are never fully transparent, always mediating how the world is experienced. According to Haff's systemic approach, the reason is the existence of large-scale dynamics that escape human control, whose effects trickle down to influence smaller-scale phenomena. As we will see below, this account still leaves space for contingent developments, and does not necessarily amount to a form of determinism. It might thus be a little bit of a stretch to consider the technosphere, as Lemmens, Blok and Zwier (2017, 116) seem to hint, comparable to Heidegger's conception of modern technology as the all-encompassing ontological view of the Enframing.[7] What the technosphere does, nonetheless, is to largely reduce the possibility of human beings to influence large-scale phenomena, disregarding the role of politics and social groups.

Before taking a closer look to the place of human agency in the technosphere, however, a critical observation should be made on the relationship between the technosphere and technology in general. The human-independent, quasi-autonomous character of the technosphere does not only lie in the fact that its dynamics are essentially outside of human control, but is also visible in its origin.

> The technosphere is not 'just' a human-created phenomenon, because, except for simple artefacts like stone tools, humans did not create technology independently, but only in the context of existing technological systems. From the outside, that is, from its own vantage point, notwithstanding that its human parts are essential, technology appears to have bootstrapped itself into its present state (Haff 2014a, 302)

This conflict between the human perspective and that of the technosphere makes us wonder about the difference between the evolutionary history of tools, especially stone tools as the first example of human technology, and the history of the technosphere's development. Stone tools are, for Haff, excluded by the technosphere's autonomous dynamics, because they arose due to human action, independently from any technological systems. This seems to create an explanatory fracture between the evolutionary history of human technology use, and that of the technosphere. On the one hand humanity actively developed the first technological tools independently from other technological systems. New tools then enabled the progressive development of more complex instruments and systems relying on the availability of the former ones. On the other hand their creation gradually gave rise to the growing dynamics of the technosphere, with their increasing autonomous character. Because of this autonomous dynamics, the technosphere does not seem to be reducible just to the artifacts that support its operations. The entanglement of human and

[7] This is not to say that parallels could not be drawn, but the two concepts remains fundamentally different ways of thinking about technology. One would otherwise need to devise a philosophically solid way to connect Heidegger's idea of Being to system/part relationships as conceived by system theory.

technological agency thus complicates the picture of how we should think about the relationship between the technosphere and the technologies that make it up.

This is further complicated by Haff's use of "technosphere" to talk about different technological and social systems belonging to different historical moments and spatiotemporal scales. Haff considers the historical trend of expansion of the technosphere through the rise of nation states based on sedentary human settlements dedicated to agriculture. To describe their failure to extend their hegemony over hard-to-access mountainous regions, Haff speaks of an "early technosphere" (Haff 2014a, 303). By contrast, the "modern technosphere", with the development of large-scale transportation infrastructures through land, sea and sky, is better equipped to exert its influence over once inaccessible regions. From an evolutionary and historical perspective therefore, the technosphere appears as the development of broad social and technological (we could say sociotechnical) dynamics that are not completely in control of single individuals and that heavily affect the landscape and its human populations. It seems then misleading to understand the technosphere as just a synonym for technology in general as a set of technical artifacts, given the interwoven character of human agency and larger sociotechnical dynamics. The evolutionary history of the technosphere does not coincide with the history of technological tools, but the two can, instead, be studied through their interrelations.

For the aim of this chapter to reveal the way in which the technosphere describes global human-technology relations, all of this means that we should now turn to the social and political aspects of the technosphere, that is, to the role played by human agency in its evolution. If, as we concluded in this section, Haff argues against technological instrumentalism without endorsing full-fledged determinism, and the technosphere does not coincide with a set of technical objects, then the human side of human-technology relations is what is still left to be analyzed.

2.5 Politics in the technosphere

The global scale of technology, for Haff, implies a revision of the instrumentalism of the Anthropocene narrative, and an attribution of autonomy to the technosphere that, albeit not resulting into a form of absolute technological determinism, deprives human beings of substantial power of influence. With this in mind, let us have a closer look at the global scale of social and political interactions with the technosphere, and gain a better view of the human side of global human-technology relations. The status of human agency within the technosphere, in fact, appears ambiguous at best. Contemporary human populations are certainly deeply dependent on the technosphere for their survival and well-being. Without its support, according to Haff the human population would drastically decline in number to Stone Age levels of around ten million individuals (2014a, 302). On the other hand human beings are also essential for the technosphere's functioning, without whom the latter would cease to exist. The technosphere's autonomy seems to depend on its ability to co-opt human beings into collaborating for its maintenance. In other words the technosphere and its human components depend on each other for their survival, and their respective agencies co-shape each other. However this co-dependency does not entail a symmetrical power of influence, according to Haff's model. In order to understand the place of human social and political agency in the technosphere, we need to delve deeper into the relationships that regulate their mutual interactions.

Considered as a system the technosphere has a function: "extract high quality energy from the environment and to do work with that energy to sustain its own existence and that of its parts,

including humans" (Haff 2014b, 133). It is essentially a metabolic system, meaning that it displays regulation mechanisms that ensure its ability to obtain the energy it needs in order to maintain its functionality and survive. These mechanisms are presented by Haff (2014b) through six rules that clarify the relationship between the technosphere and its components at different scales, human parts included. These rules describe the constraints that any ordered system is subjected to because of its being ordered. In order to display coherent dynamics, the parts of an ordered system need to respect certain rules that *regulate* their mutual relationships, and the interactions with the whole system. For this reason they are called *regulative*, describing system-part relationships in an abstract manner independent from the particular instantiation of a system (Haff 2014b, 128).[8] As we will see, by employing this system-part approach, Haff constrains his analysis to human individuals, missing the role played by the agency of larger social groups in the co-evolution of the technosphere.

Two rules are of fundamental importance to understand the mutually beneficial relations between human beings and the technosphere. According to the rule of *performance*, "at least some of the actions of most system parts must support the function of the system to which they belong" (Haff 2014b, 133). According to the rule of *provision*, the "host system contributes to maintenance of a suitable environment for its parts" (Haff 2014b, 134). These rules explain why human beings are bound to and by the technosphere. The technosphere, as a system, makes sure that its human parts collaborate in maintaining its function. Consequently, it *provides* an environment that is optimized for the functional well-being of its parts. In this way, the human components of the technosphere have the possibility to thrive and *perform* operations that are beneficial to the technosphere itself. The constraints imposed by the technosphere on its human parts in the form of its provisions imply that it becomes increasingly harder to renounce to it. However this binding is not absolutely irresistible, especially if we consider that these rules do not apply in the same way to all humans, providing abundance of resources for some, while causing pollution and poverty for others (Peterson and Zahara 2016).

How much space does Haff leave for human agency within the binds of the technosphere? According to Haff's application of systems theory, three other rules regulate the relationship between a system and its components. In general, parts that inhabit different scales of the system can interact only indirectly. According to the rule of *impotence*, human beings are unable to affect the development of the technosphere *directly* through their actions. Symmetrically, the rule of *inaccessibility* makes it impossible for the technosphere to control all the details of human lives, because these occur at a scale that is too small for the macro-processes of the technosphere to reach and influence. Consequently, according to the rule of *reciprocity*, only systems that can interact on the same scale are able to interact directly. Human beings, for example, can interact directly with human-sized technological artifacts such as computers and cars. However if a human being has to reach the more minute components of such artifacts, he or she could only do so through the mediation of an instrument that enables interaction at such smaller scale. Interaction between systems inhabiting different scales is therefore possible only *indirectly*, through the mediation of assemblages of other (sub)systems whose scales partially overlap, putting two different scales in connection.

[8] System rules that depend on the particular system being considered, and therefore do not apply to all systems in general, are called *constitutive* rules.

What these rules entail is that the technosphere is almost a "separate entity" compared to human individuals and technological artifacts, since they do not interact directly. The global dynamics of the technosphere do not appear to strictly determine the actions of its parts. Rather, the technosphere puts in place a series of general constraints that act in locally different manners, thereby making it more convenient to comply, and harder, but not impossible, to resist. The technosphere makes it so that its human components are encouraged to act in ways that sustain the technosphere's metabolism, for example by granting more food or easier access to useful resources. These forces do not lead to a deterministic developmental path, as many of these effects are localized and not equal everywhere, leading to very different effects. When considering the technosphere's need to develop recycling mechanisms to sustain itself in the future, Haff admits that whether this will happen remains essentially undetermined (Haff 2014a, 305).

Nonetheless, what it does entail is a sensible reduction of human agency to influence the large-scale processes of technology and society. Global human-technology relations within the technosphere remain, as a consequence, strongly asymmetric. It must be acknowledged, in fact, that Haff's conception of the technosphere is still that of an essentially self-determining system, which sets its own 'goals' and regulates its parts in order to ensure its own survival. Human beings are able to influence the technosphere only to a moderate degree. Developmental constraints are oriented mainly from the technosphere to human beings, rather than in both directions. The large-scale effects of the technosphere exert a stronger downward influence than any upward effect caused by smaller-scale social phenomena. As a consequence of this asymmetry, human beings "are locked into technospheric feedback loops of performance and provision, sometimes gladly, sometimes not, but from which position they cannot exit without peril to necessities of existence" (Haff 2017, 108).

While Haff emphasizes the inner workings of the technosphere that are independent from human choice, the impression we gain from what has been discussed up to here is that he seems to be sketching a theory that might still leave some space for the possibility to study how the various parts of the technosphere influence its overall dynamics. Donges et al. (2017) offer a qualitative model of the technosphere as an adaptive social-technological-ecological network, that looks like a promising step towards developing a framework that acknowledges the mutual co-evolution and co-shaping of large-scale technological and social processes. Based on complex systems theory, it accounts both for the societal interactions between human individuals and social macrostructures, and for the large-scale sociotechnical dynamics between social macrostructures and technological macro-infrastructures, these last two together forming the technosphere. In this way the authors consciously reframe the development of technology from an autonomous process to a political question that concerns collective social agency. Their model addresses what is left out by Haff, namely the relations between human individuals and larger social groups, and between the latter and large-scale technical systems. As the collective agency of social macrostructures has a fundamental influence on the future of the technosphere, it is crucial to include social and political relations between individuals and groups, and between social macrostructures and large-scale technological infrastructures, into our understanding of the technosphere. They redefine the technosphere as a network of co-evolved interactions and feedback loops between social and technical elements, with individuals and societies shaping technologies, and societies adapting to maintain technological systems.

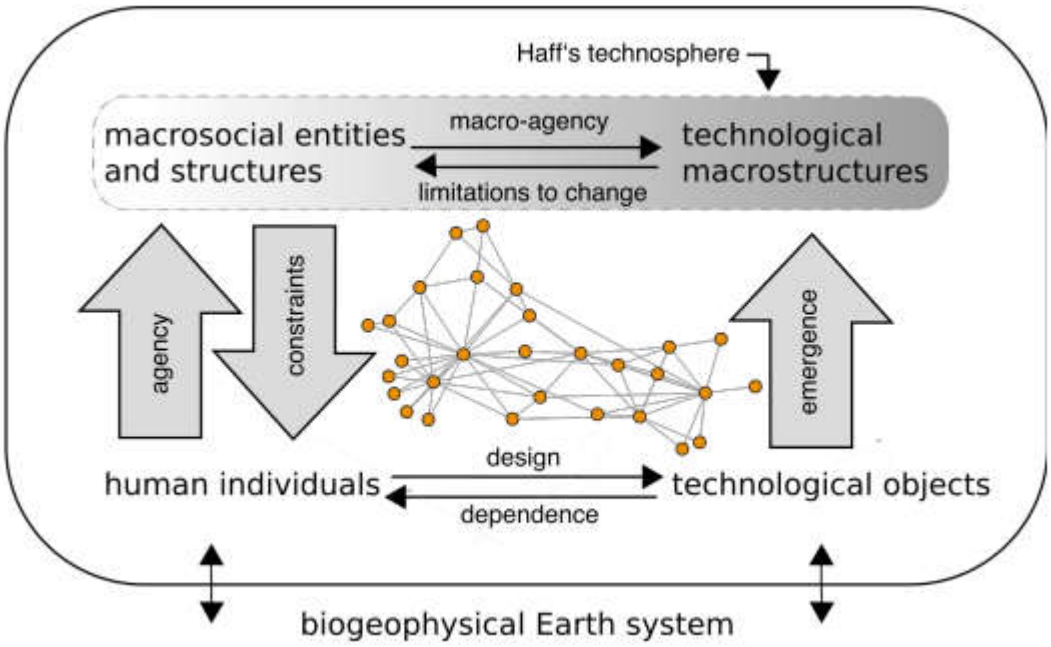

Figure 1 - A qualitative model of the technosphere that acknowledges the influence of social actors (Donges et al. 2017)

What can we conclude from this exploration of Haff's account of the technosphere as an approach to understand global human-technology relations? The technosphere represents a large-scale dynamic system that is formed by technological and social systems, single artifacts, human beings and the resources it appropriates from the environment. While it revises the technological instrumentalism of the Anthropocene narrative, its macro-scale perspective is in line with the approach of the Earth system scientists, resulting in a severe limitation of the agency of individuals and a disregard of the large-scale political influence of social actors. Since its development is still open and contingent, but the technosphere is supposed to constraint its parts much more than they are singularly able to influence it, Haff's model might serve as an indirect justification for large-scale top-down projects of planetary management, that attempt to exert a strong enough influence to steer its course.

The question whether the technosphere is already an established system, however, is still open. It seems then that philosophers and other scholars of technology should have a thrust and provide accounts for the global scale of human-technology relations, filling in the details of the various social and technological processes that supposedly compose the technosphere, as the trail blazed by Donges et al. (2017) shows. Waste is a particularly interesting way to start this exploration. Given the contemporary planetary scale of anthropogenic waste and that the technosphere's existence is currently challenged by its own waste flows, understanding how waste comes to be identified as such through the large-scale interactions between social and technical systems, offers a revealing entry point on the global scale of human-technology relations. In the next section we will see how what we discovered up to here about the technosphere's framing of global human-technology relations is reflected in Haff's treatment of waste. Opening up the issue of waste will then lead us to ask, in the next chapter, further questions about how paying attention to waste's complexity reveals further limits of Haff's account, and how it can be used to sketch a helpful path to address the large scales of human-technology relations in the anthropocene.

2.6 Technospheric waste

Up to this point, we have examined how global human-technology relations are framed within Haff's technosphere framework, in connection to the anthropocene debate, and the way in which he describes technology and social actors. It was discovered that Haff argues against technological instrumentalism as found in the Anthropocene narrative, but his model inherits the disregard of the latter for the influence of society and politics on the evolution of technological processes. This section will illustrate that this asymmetry between technological factors and social forces entails that waste is defined through a strict technocentric logic. In this way it should become clearer how an account of waste that includes a consideration for social and political forces would do a better job at approaching global human-technology relations, as we will see in the next chapter.

According to Haff, "every metabolizing system must eventually recycle its own waste products (or rely on other systems to do so), otherwise accumulation of *spent material* (i.e. *pollutants*) will impair system function" (Haff 2014a, 305, emphasis mine). The waste of the technosphere, therefore, is constituted by anything that does not serve or that obstacles its functioning. In this sense it can be indifferently material or social.

Concerning material waste, Zalasiewicz et al. (2017), in a paper co-written with Haff, distinguish between active and residual layers of the technosphere. The second one is formed by all those materials "at the end of their useful life" (Zalasiewicz et al. 2017, 11), many of which have a remarkable long-term preservation potential.[9] Any residual material that cannot be reinserted into the cycles that sustain the technosphere becomes waste. While this perspective could be accused of betraying an idea of continuous exploitation of value, it is more appropriately understood in connection with physical and biological ideas of a system maintaining its order, i.e. low entropy, through a flux that increases the entropy of the environment (Haff 2014a, 304). In the context of global ecology, however, the dichotomy between active and inactive materials could be challenged as betraying a still anthropocentric view. According to whom is a material active or not? What are the consequences of treating as inactive a material that acts on parts of the world that are ignored? By examining how certain parts of the residue layer remain active and for whom, as Rosol et al. (2017) cleverly suggest, it is possible to challenge the idea of an "end of life" of technological objects, exploring how waste lingers around and "haunts" certain places, human beings and ecosystems. The disregard for the influence of social perceptions of waste on the large-scale dynamics of the technosphere, thus, is clearly apparent in the treatment of waste materials as active and residual.

Concerning social forms of waste, Haff refers to categories of people that actively oppose or do not support the technosphere's function. For example, he specifies how an adversarial leader with a broad subversive influence, such as Nelson Mandela or Mahatma Gandhi, "is a malfunctioning part as far as the system is concerned" (Haff 2014b, 133). Similarly, workers that are considered inefficient by a metric defined on a constantly evolving technosphere, such as the low-skilled, poorly-educated, ill or old, are the first one to be replaced, producing a "waste stream of human components" (Haff 2017, 107). Again, this perspective could be accused of not being non-anthropocentric at all, rather quite the opposite of representing the interests of certain technocratic

[9] It is interesting to remember how the waste of the technosphere in this residual sense, the idea of archaeosphere (Edgeworth et al. 2015) or of technofossils (Zalasiewicz et al. 2014), provides a very material form of connection between the technosphere and the anthropocene: the stratigraphical evidence of the anthropocene is concretely constituted by waste as residue, the residue of the technosphere.

elites, depoliticizing their stance by assimilating it to natural tendencies of complex systems. Again, the disregard of sociopolitical forces becomes visible.

By looking at how Haff identifies waste within the technosphere, we can see how the model seems to betray a tendency to treat waste problems through the top-down managerial approach that was spotted lurking behind the Anthropocene narrative. The patterns of global human-technology relations revealed by Haff imply that only large-scale coordination is able to have any effect noticeable at the planetary scale. However, Haff offers little help to understand how the "interests" of the technosphere might become embodied in particular social institutions and technological systems. This disregard for political actors, as we have seen, is a legacy that is found way before Haff's conceptualization of the technosphere and points to a more general neglect of the social and political dimension of human life by systemic approaches to the global scale of technological humanity. In Haff's model, the asymmetry between social and technological forces is exacerbated by the one-directional emphasis of large-scale technospheric agency through technical constraints, which further stifles the possibility to envision alternative ways of dealing with global issues.

It seems crucial, then, to study in more detail how social and political actors mediate the interaction between technological processes and the technosphere's evolution. In the next chapter, we will see how a constitutive, relational and dynamic idea of waste opens the way to an approach to global human-technology relations that is more sensitive to the role of individuals and social groups in shaping these relations. Paying attention to the complexity of waste will be helpful in decentering the perspective of the technosphere, revealing the limits of Haff's formulation. An account of the dynamics of human-technology relations at the global scale needs to take the role of social factors into account. By bringing together global scale and human-technology relations, waste can serve as a conceptual tool to broaden our understanding of the global co-evolution of technology and society.

3. Dynamics of waste perception

In the first chapter we have examined how Haff's concept of the technosphere approaches global human-technology relations, and how such an approach is reflected on waste. According to Haff, the technosphere presents an essentially autonomous dynamic that denies the instrumentalist view found in the Anthropocene narrative. Such an advantage, however, is negatively compensated by the reiteration of a systemic disregard for the role of social and political forces in shaping the course of technological development, and thus the future of the technosphere. This asymmetry entails that waste is defined through a strict technocentric logic. The waste of the technosphere is constituted by anything that poses a threat to hinder or slow down its metabolic functioning. This includes refuse materials that cannot be recovered, but also social groups who are unable to work and sustain the technosphere. The problematic aspect of technospheric waste is, from the systemic perspective, its inability to be reintegrated into the system itself, remaining "inactive" (Johansson et al. 2013). This reveals the broader limits of Haff's model to account for how social perspectives and political forces contribute to shape the global development of technology.

How is it possible to recover the social and political dimension of global human-technology relations, by attending to the social and technical dynamics that define what counts as waste? In order to provide an answer to this question, this chapter will be devolved to the analysis of a revised conception of waste, that is able to account for the role of social forces in their interaction with technical systems. Thanks to such a concept of waste, the limits of Haff's account of global human-technology relations in the technosphere will become more apparent, and a way to address these shortcomings will be offered. This way entails examining how the boundaries between waste and value are sustained and disrupted by an interplay of social and technical factors at different scales, as it will be clarified in just a moment. Both extremes of assigning all agency either to the micro-scale human components, as a naïve instrumentalist view would do, or to the large-scale technological constraints of the technosphere, as Haff does, seem equally problematic and simplistic. In order to refine the understanding of global human-technology relations provided by the technosphere, the social and political dimension needs to be recovered by paying attention to how social actors and technical infrastructures symmetrically interact to shape the course of the large-scale sociotechnical developments of the technosphere.

How can the concept of waste be useful to accomplish this task? Because of the disregard for the human perspective, what is missed from Haff's technocentric view of global human-technology relations is the possibility to critically evaluate and potentially challenge technological developments that might lead to unjust or poor conditions for many of the living parts of the technosphere. In the case of the global dimension of waste, this means the very systemic processes of boundary-making that divide order and disorder, waste and value, and distribute the effects of how waste is treated. Attending only to the macro-scale perspective of the technosphere poses a risk to take for granted and calcify existing social and material boundaries that divide people and places affected by large inequalities (Peterson and Zahara 2016). This is simply a consequence of the tendency of the systemic approach to naturalize political factors into physical dynamics. In an attempt to detach our view from an anthropocentric perspective, Haff might end up re-centering it by assimilating it completely to the technocentric perspective of the technosphere. It becomes crucial, then, to understand how these boundaries are made and unmade, in order to gain a better grasp of the large-scale interactions between the social and technological factors that shape them. It is for these reasons that an examination of waste offers a fruitful way to criticize, and amend, the

shortcomings of Haff's idea of the technosphere as an approach to global human-technology relations. Being an inherently normative concept, paying attention to how waste becomes identified as such grants an easier access to the factors that influence such identification. Since in the globalized world of the anthropocene these factors are constituted by large-scale relations between human beings and technological infrastructures, they are formed both by social and by technical aspects, as we will see in what follows. Therefore,

Therefore, this chapter will explore a way to conceptualize waste that reveals how both social and technical relations in waste disposal practices mediate global human-technology relations. A definition of waste as a constitutive, relational and dynamic category produced by boundary-making practices will be argued for, in order to recover the complex symmetry of interactions between human beings and technological systems that the technosphere was found to fail to account for. Firstly, through an analysis of the richness of waste semantics, the lack of nuance of Haff's conception of waste will be illustrated (§3.1). Then, a constitutive role of waste will be argued for by critically reflecting on Mary Douglas' concept of dirt (§3.2). Subsequently, the inherent normativity of waste will be related to the particular system drawing the boundary, by showing the relational character of waste through Luhmann's social systems theory (§3.3). Having shown, thus, how waste cannot be understood independently from social actors, its dynamic character will be illustrated through Jensen's (2016) case study of Phnom Penh's sewage infrastructure (§3.4). The interaction between social components and technological infrastructures in Phnom Penh shows how large-scale sociotechnical systems actively shape how waste is perceived and judged. In this way, by understanding waste as the constitutive, relational and dynamic product of boundary-making practices, it will become possible to reveal how complex large-scale human-technology relations are at play in shaping the world of the anthropocene, inviting us to further problematize and explore the behavior of the technosphere (§3.5).

3.1 The semantics of waste

This section and the next two will work towards the formulation of a concept of waste that takes into account its structural, social, and material nature, and how its identity changes through waste disposal practices. By following the inherent normativity of waste, the social and political factors that are involved in its identification can be addressed and recovered. The first step towards this goal is to map the different conceptual meanings of waste, in order to gain a better sense of the nuances contained within the normative dimension of waste. This will show the limitation of reducing waste to the polluting residue that hinders the technosphere's metabolism, and point towards a richer notion.

Talking about waste, and especially about its philosophical importance, might appear as breaking an implicit taboo. Talking about discards makes visible what public decency and moral character demand remains hidden. Technological objects are made, used, and discarded. All these phases occur thanks to, and along with, the production of waste, discards, disorder. What we throw away seems to stands as the awkward and shameful testimony that reminds us of the origin, background and destiny of everything we make. That is why it is promptly removed. We do not want to talk about it, we do not want to face it. Trash appears dirty, therefore we throw it away or flush it down the pipes, making it invisible, pushing it out of sight, smell and touch. Removing waste becomes a cleansing ritual with moral and political connotations.

Given these common nuances of profanity and dirt, a philosophical history of waste might not sound as noble as a history of metaphysics or of morality. It is in fact not as easy to build grand, sweeping narratives of the history of the idea of waste, probably because connecting it to older (usually Greek) concepts is a less straightforward operation than with other ideas. If most philosophers cannot resist talking about *technē* when analyzing the nature of technology, what will they resort to when analyzing waste? Waste does not seem a "universal" category in a philosophical sense. Its names betray very regional and particular origins, related to the great number of different types of refuse we encounter. Let us start, then, from an examination of the most common semantic fields related to different terms for waste.

The words used to refer to waste are just as many as the types of things we throw away, already in the English language alone: garbage, rubbish, trash, dirt, filth, litter, discard, junk, refuse. To put some order in this chaotic mass, some family resemblances can be construed.[10] Some types of waste indicate what is left after processes of manufacture, production, or destruction: residue, leftovers, spoils, remains, and the German *Müll*, the leftovers of milling. Residual matter is usually unimportant and worthless, such as junk, the Italian *pattume*, what can be trodden upon, and the Chinese/Japanese ideogram 塵, which represents a group of running deer (鹿) producing a cloud of dust (土). If waste is worthless, then it does not matter that what is without value is left in a state of confusion and disorder, a connotation we see in rubbish and rubble. Waste is also the product of processes of decay, a word that itself comes from the Latin *de-cadere*, literally what falls-off. We can find the idea of matter falling off in the German *Abfall*, the Dutch *afval* and, residually, in the English offal, and debris, what breaks off. Waste is not only what passively falls off, but also what is actively removed: scraps, discards, detritus, and the Italian *spazzatura*, what is removed to *make space* for a certain thing to be. Waste, then, is formed by rejected things, as we can find in refuse and in the very common *rifiuti* in Italian. Similarly the idea of something disgusting is present in the words filth, scum, dirt, the Dutch *vuil*, related to the English "foul", the French *ordure*, and the Italian *immondizia*, what is unclean.[11]

This brief survey illustrates different but overlapping categories of waste: residual and excess matter; worthless matter; disordered matter; decaying and decayed matter; matter that is actively removed; unwanted matter; and disgusting matter. The etymological history of many terms for waste cuts across more than one of these semantic fields, such as scoria, used in modern English and Italian to indicate the leftovers of mining or nuclear energy production respectively, but referring to dung in the original Greek. For this reason many terms often bring together more than one field: "scraps" refers to what is actively "scraped out" but also to excess and residual parts; "rubbish" is both disordered and unimportant.

Therefore, choosing a particular semantic field as entry point to talk about waste seems more a matter of deliberate choice about what one wants to say, than a way to clarify once and for all its complete significance. The meaningfulness of waste cannot be easily exhausted, and that is why waste as a conceptual category can be a powerful tool for de-centering narratives, as we will see

[10] Moser (2002) offers a tripartite classification of waste into leftovers, decay and refuse, that I follow to an extent. I also add some more particular meanings to show the sheer variety, but also additional fundamental conceptual categories related to waste.

[11] Interestingly, the Italian noun "mondo", world, means "clean" in its adjectival form. The world is thus the *locus mundus*, the clean place, that human beings can inhabit. What is *immondo* is thus what is unclean and out of this world. There is here bears a striking resemblance to how cosmos, originally meaning "order", became a way to identify the universe as an ordered whole, as we will see below.

below. That is also why waste, as a category emerging from large-scale relations between social and technical system – which is how it is approached by Haff through the technosphere – cannot be reduced to the residue of a single metabolic process.

3.2 The constitutive structure of waste

How is it possible to avoid the naturalization and de-politicization of waste when it is considered from the global perspective of the technosphere? The aim of this section is to articulate a concept of waste as the product of boundary-making practices enacted by particular systems in order to constitute and demarcate themselves from the rest. Such a definition will move a step closer towards recovering the social and political factors that Haff disregarded when considering waste as the product of the global human-technology relations of the technosphere.

In spite of the sheer variety of meanings of waste that was found above, the stubborn traditionalist philosopher might still try to find a classic entry point to examine such a concept. The contraposition between *cosmos* and *chaos*, order and disorder, looks like the most interesting choice.[12] It can be found, in fact, in the *locus classicus* of philosophy of waste, Mary Douglas' *Purity and Danger*, where "dirt" is defined as "matter out of place" (1966, 36). As a social anthropologist, Douglas analyzes how social and cultural systems are constituted and maintained by looking at practices of rejection and exclusion of disorder in the moral, social and material domain. If what is clean and ordered is to be kept as such, then dirt as disorder must be isolated, disposed of, and ordered. This suggests an idea of waste as what is immoral, the disorder that is removed to constitute an ordered entity or system, whose existence is threatened by such dirt. Reno (2015) defines this account as "structural-symbolic", because it clarifies the structural relations that determine when something becomes identified as waste. However, there seems to be at least two issues with Douglas' definition, which point to a more complex picture than a simplistic contraposition between order and disorder. By reflecting carefully on her approach, the concept of waste we are looking for can be sketched out.

The first issue stems from a confusion about how Douglas seems to conceive waste. When Douglas further explains the meaning of dirt, she calls it a "[…] residual category, rejected from our normal scheme of classifications" (1966, 37). If the normative distinction between waste and value is established by the system, and waste is what threatens such dichotomies, then it does not belong exclusively in the realm of the negative anymore. Dirt is not just the negativity that is expelled, the *im*moral according to the system, but rather becomes the *a*moral, what exists beyond the moral/immoral dichotomy established by the system. Because of its defiance of classifications, waste might challenge the legitimacy of the system's constitution of a boundary between waste and itself. Both ways to frame waste have something to tell us, but they do not coincide: it is from the perspective of the constituting system that waste is framed as negative, while from an impartial

[12] An explicit contraposition between cosmos and chaos as order and disorder, is actually a relatively recent development in the history of ideas. Alexander von Humboldt popularized the idea of a universe that could be thought of as an ordered whole in his five-volume series *Kosmos*, published between 1845 and 1862. The word "chaos" originally indicated an empty void, the primordial abyss from which the universe formed, traces of which are still visible in the word "chasm". The contraposition between an ordered cosmos and the disorder of chaos seems to be a result that has developed starting from the 17th century through a revival of the classics such as the *Metamorphoses* by Roman poet Ovid, where he described chaos as being filled with a confused mixture of the primordial elements. Ovid's conception of chaos might have been inspired, in turn, by Plato's interpretation of the primordial void as a receptacle of formless and confused matter, to which the demiurge would give form and order (Fantham 2004, 22).

perspective waste appears as neutral. The first perspective points to waste as what is to be refused according to a system. The second points to how waste escapes the positive/negative classification imposed by the system, and could potentially challenge it. Douglas account seems to conflate these two aspects of waste.

Secondly, defining waste as what is "out of place" makes the idea of waste management a contradictory concept. When waste is disposed and put, say, in a landfill, then it would not be "out of place" anymore. According to Douglas' definition, therefore, when waste is moved to a landfill it would cease to be waste, since it would be "in its place" (Gille 2013). Defining dirt in terms of its place creates an inherent relation with the boundary of the ordered system. Waste is such only within the system, and is designated as what should be removed. Once it is removed, then it stops being waste. This seems problematic if we consider the amount of effort that is exerted to keep waste disposal facilities in order. We might want to consider landfills and nuclear waste deposits as parts of the ordered system rather than lying outside of it. Space debris and microplastic would probably fit better into Douglas' definition, floating around uncontrolled, out of place in the natural environment. At any rate, based on how the boundary between the ordered system and disorder is defined, it can reveal different aspects of the system one wants to analyze. Scholars who are more interested in processes of marginalization might go along with Douglas to talk about what, despite being labeled as "to be removed", still lies around "menacingly", for example in the case of social exclusion of ethnic minorities (Sassen 2014). Scholars more interested in the ecological and material histories of waste are more likely to criticize Douglas precisely for her inability to account for the broader pathways of waste matter (Reno 2015).

Both of these issues, however, point to productive ways of developing a concept of waste that is able to embrace both sides: to account for the normativity of waste exclusion, from where waste appears as immoral/negative, while not forgetting about how its broader effects can challenge the classification system, which suggests that waste appears as amoral/neutral. This requires a different definition that does not include an explicit reference to a boundary, but rather points to the very reason for identifying something as waste. In this way, the normative nature of waste can be traced back to the origins of the distinction, while avoiding the absolutization of particular points of view.

In a very abstract and conceptual sense, waste can be defined as the product of a process of separation, in which a form of value or order is constituted through the removal of disorder, which threatens this constitution. The entity being constituted can be as different as a technical object, a living organism, the identity of a social group, or the thesis that I am currently writing. All of these are created through a process that defines a certain order within a boundary, in contraposition to what is removed or separated in order to produce such order and establish that boundary. What must be discarded is precisely waste.

Any process of constitution is a way of ordering a certain portion of reality, material or not, which, to impose a certain order, by necessity needs to get rid of disorder. This idea points to a necessity that is conceptual as much as it is ontological. The removal of disorder plays a fundamental role in the constitution of every form of order. Something valu*able* can be produced only if what is value*less* is discarded. As long as the valueless is not removed, the order of the valuable is threatened.

Framing waste as a constitutive notion points to the forces behind the processes of boundary making that identify something as waste, the reason why something is seen as waste from a certain point of view. Waste is the product of processes that attempt to establish a certain value or order and to demarcate a constitutive boundary. However such a constitutive approach seems to simply

repeat the static and absolute notion of waste that was found in the technosphere, but based on the order/disorder dichotomy. For this reason the next section will clarify how the constitutive character of waste must be understood as always relational, that is, as relative to a certain perspective. In order to avoid framing such perspectives as static and unchanging, §3.4 will then describe how the perception of something as waste is influenced by the technical infrastructures of waste disposal.

3.3 Boundaries and the relationality of waste

An obvious way of misunderstanding the idea of waste as constitutive refuse would be to take it as a fixed category. Taking waste as what is constitutively refused may seem to viciously reiterate logics of domination and exploitation, simply taking for granted the dominant view on what should be considered valueless. This raises legitimate questions about *who* decides what counts as waste. It is precisely for this reason that waste must be understood as always relational, as relative to a particular process, situation or system. Only in this way the social and political forces, disregarded by Haff, that shape what is identified as waste can be included in global human-technology relations.

The definition of waste as constitutive is different from Douglas', because the two concepts relate waste in different ways to the boundary between order and disorder, positive and negative. Dirt, as we have seen above, is "matter out of place", still lying within the boundary and waiting to be put "in its place", that is, outside of the boundary. Therefore dirt ceases to be out of place once it is removed. It rather becomes what Thompson (1979) calls "rubbish", what has been discarded and is without a value, either positive or negative: from an immoral thing, it becomes amoral, normatively irrelevant. Framing waste as constitutive refuse tries to bridge both meanings, focusing on the dynamic process of boundary making. Refuse is what is designated as "to be removed", but it is also what has been removed and sealed outside of the boundary. When refuse is expelled it must be kept out, as the efforts to safely store waste in landfills demonstrate (Gille 2013). It has been removed to constitute a certain boundary of value, but it did not cease to be waste, at least for the system that expelled it. In this way, waste as constitutive refuse extends Douglas' account outside of the boundary between order and disorder.

These boundaries, however, must not be understood as completely sealed, with things lying either inside or outside. Reality is much messier, and waste often represents a liminal presence that both bounds a certain system, and connects it to other systems and to the environment. Boundaries divide as well as link different places, groups, and systems, as German sociologist and philosopher Niklas Luhmann (1927-1998) argued. Boundaries separate different social, political, and value systems, for example two nation states, the city center from the periphery, the rich from the poor, the advanced from the outdated. However they also put different systems in relation to each other (Luhmann 1982). Waste, by moving across system boundaries, represents one form of connection. The plastic that is thrown away in the US can end up in the middle of the Pacific Ocean in an oceanic gyre. The electronics that are thrown away in Europe can end up in African dumps. Boundaries are not only what individuates a certain system, but they are also what allows one system to relate to other systems (Luhmann 1982, 237), for example by allowing them to recognize whose waste a certain material is, and how it affects them.

Because of the social and material properties of waste, in fact, other systems of value might still find use of the waste one system has refused. What a middleclass person in New York throws away might become the shelter of the homeless. What the homeless throws away might acquire aesthetic

value and become "New York City Garbage", a treasure for the riches (Whiteley 2010, 6). From the outside perspective of the environment, in the sense of Luhmann (1982), waste can be framed as amoral or normatively neutral. Waste is framed as negative only in a *relational sense*. Waste is always waste-*for* a system. In this way, through Luhmann's theory of social systems, it is possible integrate the lesson of Thompson's rubbish to Douglas' intuition about the structural properties of waste. Detaching our view from the particular system expelling its own waste, following this waste outside of the boundary we see how for other systems those materials could not constitute waste, but useful resources or neutral objects.

The definition of waste as constitutive refuse, therefore, is better thought as indicating the product of a process of continuous boundary making that is always open for contestation because of its relational character. Rather than reifying waste as what is essentially and inescapably refused, it can be agreed with Gabrys that the "[…] ambiguity of determining when waste definitively becomes waste points to its role as a dynamic category. Waste oscillates in relation to ordering systems and structures of value" (Gabrys 2011, 16). Defining waste as what is rejected in relation to the constitution of a particular form of order and value, therefore, is a way of understanding the relativity of waste in relation to particular systems. Waste is always *waste of* a certain system and therefore *waste for* a certain system, and this relative character can be recognized by other systems. This conclusion suggests focusing on practices and technologies of waste disposal as forms of boundary making.

3.4 The dynamic identity of waste

If relationality softens the character of absoluteness that a constitutive notion of waste seems to bear, their combination still looks very static. On one side it acknowledges that waste is relative and, therefore, that the global human-technology relations that influence the boundary-making processes that identify it as such are fundamentally social and political. On the other side the notion of waste as constitutive and relational does not yet offer a satisfactory way of understanding the dynamicity involved in the interactions between social and technical systems at large scales. This dynamic character of global human-technology relations is due both to their social embeddedness, as we saw above, as well as to the influence of technological systems. In this section, therefore, we will see how waste disposal practices and technologies are not neutral in themselves, but actively shape what is identified as waste.

With the previous section we arrived at a definition of waste as the constitutive and relational refuse of boundary-making processes. A potential limitation or confusion of applying social systems theory to waste is that it blurs the contrast between two different moments about waste disposal: when something is identified as waste, and when such waste is actively removed. The aim was to reveal the reasons that make something be labeled as "to be removed", namely that its necessary removal serves the constitution of a form of order or value. As such, whether and how identification and removal need to be distinguished was not considered. This risks to frame what is identified as waste as "always already" removed, downplaying or blinding us to the details of the different processes that underlie each of them. Processes of waste identification are not the same as processes of waste disposal, which presuppose that waste has been already identified as such. Talking in general about exclusion, separation or boundary making conflates both meanings, because it refers to what is semantically excluded, labeled as waste, but also materially removed, disposed as waste.

This limitation must appear painfully clear to discard studies scholars, to whom the distinction between waste identification and waste removal is crucial to distinguish different social and historical processes. However analyzing these two moments through a single analytic category seems fruitful to understand how the two aspects are inextricably interrelated. Practices of waste disposal influence what is identified as waste, and with what consequences. In turn, what is identified as waste and how, might encourage certain disposal practices rather than others. Therefore it is necessary to examine the role played by large-scale technical systems, such as waste disposal infrastructures, in shaping global human-technology relations concerning waste.

If the removal of waste is what makes ordering possible, as the constitutive notion of waste afforded, then waste disposal practices, as processes of boundary making, can be interpreted as ways to concretely realize the exclusion of what has been identified as unwanted waste. The elimination of waste derives from and materializes the normative dispositions of the ordered system, realizing the boundary that has already been drawn between the wanted and the unwanted. Waste disposal practices, conversely, do not only take care of waste by moving it away, out of sight, but they also bear crucial symbolic and material properties that influence how material refuse is perceived. In this sense every act of waste disposal, a "*cosmic*" act of ordering, is also a *cosmetic* act, an operation that shapes the value of the thing being disposed, and of the system thereby created (Scanlan 2005, 65–66).[13]

This makes it so that different societies and cultures have different degrees of perception about what constitutes a dirty road, a messy house, or whether an object should be thrown away rather than repaired. The huge production of consumer goods in many industrialized societies, coupled with efficient ways of disposing of "outdated" things by rapidly removing them "away", out of sight, makes it easier to discard, say, a perfectly functioning but "outdated" mobile phone, and just buy a new one. The availability of waste disposal infrastructures is naturally not the only factor that plays into the processes that shape waste's identity. Production, trends, material contingencies, cultural habits and other social and material factors also contribute to influence if an object is perceived as valuable or valueless. Means of waste disposal as practices of boundary making do not therefore strictly determine how waste might be perceived, but they are definitely not just a neutral instrument to carry out a predetermined goal.

Etymological and conceptual acrobatics, however, do not prove a point. Let us see this dynamics operating in a real waste disposal infrastructure of large social and material scale. STS scholar Casper Bruun Jensen described, in his 2016 paper, how sewage infrastructures in Phnom Penh, the capital city of Cambodia, influenced the way in which waste was perceived (if at all) and judged. Waste disposal infrastructures, according to Jensen, shape different patterns of activity that "impose certain kinds of order and disorder on bits of the world" (Jensen 2016, 6). In the case of Phnom Penh's sewage infrastructure, Jensen discovered that the problem of clogging that would form during heavy rain came to be attributed to different causes by groups that interacted with the sewage system in different points and ways. According to the municipality, the source of the problem lay in the cultural habits of disposing waste by throwing it in the streets (Jensen 2016, 13). According to the people living around the market square that would flood because of the clogged pipes, the responsibility lay in the hands of the company responsible for picking up the trash, and in the municipality that did not work adequately enough to ensure that the pipes functioned to avoid

[13] Interestingly enough, the Dutch word for cleaning, *schoonmaken*, bears a similar conception. The word "schoon", in Belgian Dutch, has retained its meaning as "beautiful", as it is also visible through its German cognate "schön", and in relation to the Dutch word for beauty, "schoonheid". *Schoonmaken* is making something beautiful by cleaning.

flooding (Jensen 2016, 16). These different perceptions did not arise randomly, but were shaped by contingent assemblages of people, trash, pipes, rain water and cultural imaginaries, that created patterns of activity that made some things more or less visible to different people.

This example illustrates how waste disposal infrastructures materialize boundaries by implementing certain directives – what should be removed and how – but they also actively shape, while not determining, if and how waste is perceived. Through this form of infrastructural mediation, "pipe dreams can thus be seen as *emanations* of infrastructural arrangements – rather than primarily symbolic or political" (Jensen 2016, 7). Pipe dreams, expressing the wishes of the people involved with the sewage system, influenced the infrastructure, but infrastructures also shaped back social hopes and dreams.

The scale of Jensen's case study is that of a chaotic Southeast Asian metropolis, which displayed very intricate connections between its different parts, human and technological. At the global scale, the role of large-scale infrastructures in shaping ranges of perception is even greater. When waste travels around the globe, it becomes invisible for people in one place, while becoming very visible for people somewhere else on the planet. Mobile phones discarded in Europe and America because they are out of fashion become a treasure for the poors of Africa (Nnorom and Osibanjo 2008). Old cargo ships can be assembled in the high-tech docks of Sweden, but disassembled and scrapped by untrained and unprotected workers in Bangladesh (Gregson et al. 2010). Travelling around the world, waste is perceived differently, and influences the conditions of people and ecosystems. In this way waste materially connects the places it travels through, while also contributing to their segmentation along dynamic boundaries that are sustained or challenged by the patterns of global human-technology relations surrounding waste infrastructures.

By paying attention to the way in which waste disposal infrastructures influence how waste is perceived, the dynamic character of waste has been recovered, as this section illustrated. Infrastructures of waste disposal do not merely obey the task they are put to serve, embodying a rigid normative boundary, but they also influence social and political processes that might lead to their contestation. The category of waste becomes the dynamic product of complex social and technical interactions surrounding large-scale infrastructures. These interactions between social actors and technical infrastructures influence the ranges of perception available to different people, shaping the formation and disruption of boundaries between what counts as waste and what does not. The next and last section will flesh out what understanding waste as a constitutive, relational and dynamic category entails for making sense of global human-technology relations.

3.5 Dynamics of waste perception in the anthropocene

This chapter argued for a concept of waste that addresses the shortcomings of Haff's treatment of human-technology relations through the technosphere. As it was shown in the previous chapter, these limits lie in the asymmetrical treatment of global human-technology relations. The technosphere privileges large-scale technological dynamics and downplays the role of social factors. To make up for such an asymmetrical treatment, this chapter offered a way to approach waste that accounts for its constitutive, relational and dynamic character. How is this helpful in refining our understanding of global human-technology relations?

By considering waste as an inherently normative concept, framing it as constitutive relates its origin to the forces behind the processes that lead to its formation. In other words, treating waste's normativity as constitutive means that something is not treated as waste without a cause. This cause

can be traced back to the interactions between social and technical systems, as exemplified by Phnom Penh's sewage infrastructure. The boundaries that identify some materials as waste are created and disrupted by patterns of activities that link human beings and technological infrastructures.

Paying attention to the relational character of waste prevents concluding that its constitutive aspect entails some form of absoluteness. Waste is always waste-for, which means that when something is identified as waste, it is never inherently. This aspect dispels the impression of neutrality that the concept of waste had within the technosphere, and it points to the political forces hidden behind it, that would justify a top-down technocratic and managerial approach.

The dynamic character of waste served to bring again together the social and technological forces that co-shape the large-scale dynamics of technology and society. What counts as waste and for whom is a result of a complex network of interactions between human beings and large-scale infrastructures. Methodologically, this means avoiding the endorsement of an asymmetry between technological and social agency at the large scale, and studying the complex feedback loops between technology and society. The examination of waste infrastructures, in particular, suggests that this study can be done by researching the ways in which infrastructures influence the perception of social actors, both individuals and groups, and, consequently, how they formulate their action plans that will influence back the infrastructure itself and other systems. Not only STS, but also postphenomenological approaches could engage with this task, by reconstructing the ways in which global human-technology relations play out through large-scale infrastructures.

What does this say about approaching global human-technology relations through the lens of waste? Conceptualizing waste as the relational product of dynamic sociotechnical processes enables the re-politicization of global issues, and points to the interactions between human beings and infrastructures as the place where to study these negotiations. Some of these boundaries are in place across the world, for example as drives for efficiency that make certain forms of human labor obsolete. However these boundaries are rarely stable for long. How social actors draw them has real world consequences on how particular materials are treated, by whom, and with what consequences. Conversely, large-scale material arrangements do not only materialize these boundaries, but they also shape the processes that bring to their contestation. As waste is made invisible by social and material boundaries, it tends to "bite back" (Tenner 1996), exerting unexpected effects that might be politically mobilized to lead to a change in what types of waste are produced, or how they are managed.

This potential for re-politicization is also clear if we re-examine the consequences of Haff's concept of waste. From the perspective of the technosphere, in order to thrive it would need to recycle all of its waste stream. What does a constitutive and relational account of waste have to say about such ideals of zero-waste? The systemic idea of eliminating waste altogether would identify waste materials as what does not re-enter the active processes of the system (Jochem Zwier et al. 2015, 357), and lies "inactive" (Johansson et al. 2013). Through innovative technological means it would then develop ways to put them to serve some function. It in this way, far from being waste free, the ideal of zero-waste would become yet another waste regime, which draws new boundaries that can be material as much as they are moral – active/inactive, efficient/inefficient, virtuous/vicious, sustainable/polluting – which could in turn lead to other forms of inequality or marginalization of those parts that fails to reuse waste. Paying attention to the constitutive, relational and dynamic aspects of waste reveals that apparently neutral approaches always betray political perspectives embedded within certain sociotechnical systems.

In conclusion, by addressing through the lens of waste the shortcomings of the technosphere in dealing with global human-technology relations, it is possible to conclude that it is necessary to pay equal attention to social and technological dynamics. The reason is that by ignoring the complexity of large-scale interactions between social and technological systems, factors that play a crucial role in co-shaping the evolution of the technosphere are missed. Furthermore, the risk is that the de-politicization of social factors will lead to technocratic approaches of planetary management, and prevent the possibility to look for viable alternatives.

4. Conclusion

The aim of this thesis has been to employ waste as an entry point to evaluate the way in which the technosphere frames global human-technology relations, and to address its shortcomings. Enlarging the scope of the study of technology to embrace global relations is becoming a pressing issue in the anthropocene for philosophers of technology, and the concept of technosphere, as formulated by Haff, is enjoying wide popularity for the task. In chapter 2 the concept of technosphere has been analyzed in connection to the anthropocene debate and to waste, in order to reconstruct how it conceptualizes human-technology relations on a global scale. Employing the approach of systems theory, Haff thinks the technosphere as a global metabolic system composed by large-scale technological infrastructures and bureaucratic systems, technological artifacts, human beings and other forms of life, that extracts energy from the environment to power its functions and sustain its existence. Single individuals cannot influence the technosphere directly, because it exists on a scale that is too large compared to the scale of single human beings. Although the technosphere is not able to strictly determine the conditions of its components, their freedom of action is bound by the systemic constraints that the technosphere employs to ensure that its parts perform useful work for its sustenance. The consequences of this approach are clearly visible in the technocentric definition of waste as anything that hinders the metabolic function of the technosphere. The idea of technosphere disregards the influence of social factors in shaping its large-scale dynamics, and emphasizes the subjugation of human beings, offering a potential justification for top-down approaches to planetary management to address the current threats to its future existence, the lack of efficient recycling of resources and the widespread degradation of the environment.

In order to gain a picture of global human-technology relations that accounts for the role of social influences on large-scale technological developments, chapter 3 defended, with the support of discard studies, social systems theory and infrastructure studies, a concept of waste as the constitutive, relational and dynamic product of processes of boundary making. What this approach has shown is that the large-scale infrastructural processes that lead to the identification of certain materials as waste are fundamentally contingent and open-ended because of the complex networks of interactions between social and technical factors. It is not possible to understand how waste comes to be, if its social dimension is ignored. Human beings, by interacting with infrastructures (for example by maintaining them or shipping electronic waste away), influence what is perceived as waste and by whom. Therefore, humans play a role in co-shaping the large-scale dynamics that influence the perception of waste. Furthermore, the advantage of a constitutive, relational and dynamic idea of waste is that it allows the re-politicization of issues ignored by the potentially technocentric and technocratic approach that Haff's model inherited by the Anthropocene narrative.

A potential limitation is constituted by the choice of case study illustrated in §3.4. Albeit Phnom Penh is a city with more than a million inhabitants, it still represents a rather small reality compared to the truly global scale of the technosphere. As such, it might be judged as an inadequate representation of "global" human-technology relations. However it can be argued that if such a "small" case displays such an impressive degree of contingent interactions between social and technological factors, at the global scale the complexity is probably so staggeringly high that speaking with confidence about the clear existence of irresistible technological forces becomes simply unreasonable.

The technosphere appears oblivious to the influence of human parts. By assigning most of agency to the technosphere's constraints, Haff undermines the possibility to recover the social and

political factors that shape the evolution of global human-technology relations, as they were found in the processes that influence waste perception. The consequence is an indirect endorsement of the top-down approaches found in the Anthropocene narrative, motivated by a systemic skepticism of the effectiveness of local and uncoordinated activities to steer global technological processes.

These shortcomings, however, do not mean that the general concept of technosphere cannot provide any insights into the global dimension of technology. By moving the attention to the absence of clear loci of control from where to command the global co-evolution of science and technology, the technosphere could offer an entry point to address crucial questions about large-scale dynamics that assign more influence to certain sociotechnical systems rather than others. In other words, understood as the set of all those processes, technological *and* social, whose evolution escapes the *total* control of any system, the concept of technosphere can point to the contingent fluctuations that enable the consistent realization of the goals of certain systems at the expense of others. In this way, the evolution of systemic patterns of asymmetrical agency could be studied to individuate strategies of intervention to redirect systematic inequalities that are not under the clear control of anyone. As Donges et al. (2017) show, including the role of social and political factors in the technosphere is not inconceivable.

The reason for researching the technosphere has been to understand its merits and limits in offering an understanding of global human-technology relations. A potential path for philosophy of technology to approach their study is suggested by the examination of waste carried out throughout this thesis. In large-scale human-technology relations, an important role is played by infrastructures, as §3.4 illustrated. Obviously, people and places are not related only through waste, which constitutes but one example of how large-scale infrastructures influence social perceptions in different local contexts. By co-shaping patterns of visibility and invisibility between different localities and people, large-scale infrastructures mediate if and how something, such as waste, is accessible by different subjects at different points of the network. The study of large-scale infrastructures, besides and beyond infrastructures of waste disposal, is therefore an important first step towards a better comprehension of global human-technology relations.

To further sketch the way forward, two factors appear crucial to account for how these infrastructural mediations occur: the technological infrastructure itself, and the position of the subject. The design of infrastructures, their material properties, but also the cultural symbols and social meanings attached to them, are all elements that concur to shape the way in which an infrastructure mediates how a certain object or place is perceived. Infrastructures exert certain effects through their design, effects which shape perceptions in non-neutral ways, as Jensen's case study illustrated. Concerning the position of the subject, studying human-technology relations from a global scale means situating perceiver and perceived in determinate locations in the world. Where the observer and the observed object are located matters tremendously for the way in which something is perceived through large-scale technological systems. Another important question related to the study of situatedness and perception is whether and how it is possible for a subject to make sense of its own situatedness. In other words, is the situated character of perception inaccessible to the subject who finds itself in that position? If it were, a subject would be completely blind to itself. Reflexivity would be therefore impossible. The notion of infra-reflexivity comes in help to understand how a situated subject might form relations to its own situatedness. Jensen borrows the idea of infra-reflexivity from Latour, describing it as "the emergent, patterned effects of interactions as they become structured by activity trails" (Jensen 2016, 6). This approach reveals that the way in which large-scale infrastructures mediate global human-technology relations does

not only shape how other places and objects are perceived from a certain position, but also influences how subjects understand themselves (as clean or dirty, as advanced or developing etc.). The combination of this approach with an extension of postphenomenological studies to large-scale infrastructural mediations appears as paving fruitful way forward to tackle the challenge of grappling with the global dimension of relations between human beings and technologies.

Let us conclude by drawing a final corollary from the consideration that large-scale technological systems shape the way in which individuals experience the world. These influences have a consequence for how the idea of "global" should be approached. When the world is connected by large-scale infrastructures that shape the relations between different places, the meaning of "global" shifts from referring to the planet as a whole, to the relations between different local realities. The planetary scale of the anthropocene does not mean that the world has become one. Quite the opposite, it means that locations that could have been analyzed in isolation in the past have become involved in networks of large-scales relations, which mediate the way in which they perceive each other, as Luhmann (1982) similarly suggested about territorial borders. In turn, understanding how these mediations take place has political consequences. These patterns of relations influence, for example, the categories which certain places will fall into, when large-scale projects may be designed to address so-called "global priorities". Getting a better sense of how these large-scale mediations take place constitutes the main task for philosophers of technology in order to understand the global dimension of human-technology relations in the epoch of the anthropocene.

Bibliography

Asafu-Adjaye, John, Linus Blomqvist, Stewart Brand, Barry Brook, Ruth Defries, Erle Ellis, Cristhopher Foreman, et al. 2015. "An Ecomodernist Manifesto." Ecomodernism.Org. April 2015. http://www.ecomodernism.org/manifesto-english/.

Behnke, Christoph, Cornelia Kastelan, Valérie Knoll, and Ulf Wuggenig, eds. 2015. *Art in the Perifery of the Center*. Berlin: Sternberg Press.

Bjorklund, David F., Kayla Causey, and Virginia Periss. 2010. "The Evolution and Development of Human Social Cognition." In *Mind the Gap: Tracing the Origins of Human Universals*, edited by Peter M. Kappeler and Joan Silk, 351–71. Berlin, Heidelberg: Springer. https://doi.org/10.1007/978-3-642-02725-3_17.

Cooper, Tim. 2010. "Recycling Modernity: Waste and Environmental History." *History Compass* 8 (9): 1114–25. https://doi.org/10.1111/j.1478-0542.2010.00725.x.

Crutzen, Paul J. 2002. "Geology of Mankind." *Nature* 415 (23). https://www.nature.com/articles/415023a.

Crutzen, Paul J., and Eugene F. Stoermer. 2000. "The 'Anthropocene.'" *IGBP Global Change Newsletter* 41: 17–18.

Donges, Jonathan F, Wolfgang Lucht, Finn Müller-Hansen, and Will Steffen. 2017. "The Technosphere in Earth System Analysis: A Coevolutionary Perspective." *The Anthropocene Review* 4 (1): 23–33. https://doi.org/10.1177/2053019616676608.

Douglas, Mary. 1966. *Purity and Danger: An Analysis of Concepts of Pollution and Taboo*. London; New York: Routledge & Kegan Paul.

Edgeworth, Matt, Dan DeB Richter, Colin Waters, Peter Haff, Cath Neal, and Simon James Price. 2015. "Diachronous Beginnings of the Anthropocene: The Lower Bounding Surface of Anthropogenic Deposits." *The Anthropocene Review* 2 (1): 33–58. https://doi.org/10.1177/2053019614565394.

Ellis, Erle C., Mark Maslin, Nicole Boivin, and Andrew Bauer. 2016. "Involve Social Scientists in Defining the Anthropocene." *Nature News* 540 (7632): 192–93. https://doi.org/10.1038/540192a.

Fantham, Elaine. 2004. *Ovid's Metamorphoses*. 1st edition. Oxford, U.K.; New York: Oxford University Press.

Gabrys, Jennifer. 2011. *Digital Rubbish: A Natural History of Electronics*. Ann Arbor: University of Michigan Press.

Gille, Zsuzsa. 2007. *From the Cult of Waste to the Trash Heap of History: The Politics of Waste in Socialist and Postsocialist Hungary*. Annotated edition. Bloomington, IN: Indiana University Press.

———. 2013. "Is There an Emancipatory Ontology of Matter? A Response to Myra Hird." *Social Epistemology Review and Reply Collective* (blog). March 3, 2013. https://social-epistemology.com/2013/03/03/is-there-an-emancipatory-ontology-of-matter-a-response-to-myra-hird-zsuzsa-gille/.

Gregson, N., M. Crang, F. Ahamed, N. Akhter, and R. Ferdous. 2010. "Following Things of Rubbish Value: End-of-Life Ships, 'Chock-Chocky' Furniture and the Bangladeshi Middle Class Consumer." *Geoforum* 41 (6): 846–54. https://doi.org/10.1016/j.geoforum.2010.05.007.

Haff, Peter K. 2014a. "Technology as a Geological Phenomenon: Implications for Human Well-Being." Edited by Colin N. Waters, Jan A. Zalasiewicz, Mark Williams, M. A. Ellis, and A. M. Snelling. *A Stratigraphical Basis for the Anthropocene*, Geological Society, London, Special Publication, 395 (1): 301–9. https://doi.org/10.1144/SP395.4.

———. 2014b. "Humans and Technology in the Anthropocene: Six Rules." *The Anthropocene Review* 1 (2): 126–36. https://doi.org/10.1177/2053019614530575.

———. 2014c. Technosphere and Technoecology Interview by Erich Hörl. https://www.hkw.de/en/app/mediathek/video/31832.
———. 2017. "Being Human in the Anthropocene." *The Anthropocene Review* 4 (2): 103–9. https://doi.org/10.1177/2053019617700875.
Hall, Charles A. S. 1975. "Look What's Happening to Our Earth." *Bulletin of the Atomic Scientists* 31 (3): 11–21. https://doi.org/10.1080/00963402.1975.11458211.
Hamilton, Clive, and Jacques Grinevald. 2015. "Was the Anthropocene Anticipated?" *The Anthropocene Review* 2 (1): 59–72. https://doi.org/10.1177/2053019614567155.
Haraway, Donna J. 2016. *Staying With the Trouble: Making Kin in the Chthulucene*. Durham: Duke University Press.
Hecht, Gabrielle. 2018. "Interscalar Vehicles for an African Anthropocene: On Waste, Temporality, and Violence." *Cultural Anthropology* 33 (1): 109–41. https://doi.org/10.14506/ca33.1.05.
Hörl, Erich, ed. 2017. *General Ecology: The New Ecological Paradigm*. Bloomsbury Publishing.
Jensen, Casper Bruun. 2016. "Pipe Dreams: Sewage Infrastructure and Activity Trails in Phnom Penh." *Ethnos* 0 (0): 1–21. https://doi.org/10.1080/00141844.2015.1107608.
Johansson, Nils, Joakim Krook, Mats Eklund, and Björn Berglund. 2013. "An Integrated Review of Concepts and Initiatives for Mining the Technosphere: Towards a New Taxonomy." *Journal of Cleaner Production*, Special Volume: Urban and Landfill Mining, 55 (September): 35–44. https://doi.org/10.1016/j.jclepro.2012.04.007.
Klingan, Katrin, Christop Rosol, Nick Houde, Nick Müller, Johanna Schindler, Mira Witte, Bernard Geoghegan, and Anna Luhn. 2017. "Technosphere." HKW: Haus Der Kulturen Der Welt. September 21, 2017. https://www.hkw.de/en/programm/projekte/2015/technosphere/technosphere_mehr_informationen/technosphere.php.
Lemmens, Pieter, Vincent Blok, and Jochem Zwier. 2017. "Toward a Terrestrial Turn in Philosophy of Technology." *Techné: Research in Philosophy and Technology* 21 (2–3): 114–26. https://doi.org/10.5840/techne2017212/363.
Lorimer, Jamie. 2017. "The Anthropo-Scene: A Guide for the Perplexed." *Social Studies of Science* 47 (1): 117–42. https://doi.org/10.1177/0306312716671039.
Luhmann, Niklas. 1982. "Territorial Borders as System Boundaries." In *Cooperation and Conflict in Border Areas,* edited by Raimondo Strassoldo and Giovanni Delli Zotti. Milano: Franco Angeli Editore.
Malhi, Yadvinder. 2017. "The Concept of the Anthropocene." *Annual Review of Environment and Resources* 42 (1): 77–104. https://doi.org/10.1146/annurev-environ-102016-060854.
Milsum, J. H. 1968. "The Technosphere, the Biosphere, the Sociosphere Their Systems Modeling and Optimization." *IEEE Spectrum* 5 (6): 76–82. https://doi.org/10.1109/MSPEC.1968.5214690.
Moore, Jason W. 2016. *Anthropocene or Capitalocene?: Nature, History, and the Crisis of Capitalism*. Oakland, CA: Pm Press.
Morton, Timothy. 2013. *Hyperobjects: Philosophy and Ecology After the End of the World*. Minneapolis: University of Minnesota Press.
Moser, Walter. 2002. "The Acculturation of Waste." In *Waste-Site Stories: The Recycling of Memory*, edited by Brian Neville and Johanne Villeneuve, 85–105. Albany, NY: SUNY Press.
Naveh, Zev. 1982. "Landscape Ecology as an Emerging Branch of Human Ecosystem Science." In *Advances in Ecological Research*, edited by A. Macfadyen and E. D. Ford, 12:189–237. London: Academic Press. https://doi.org/10.1016/S0065-2504(08)60079-3.
Nnorom, Innocent Chidi, and Oladele Osibanjo. 2008. "Electronic Waste (e-Waste): Material Flows and Management Practices in Nigeria." *Waste Management (New York, N.Y.)* 28 (8): 1472–79. https://doi.org/10.1016/j.wasman.2007.06.012.

Peterson, Jesse, and Alex Zahara. 2016. "Anthropocene Adjustments: Discarding the Technosphere." *Discard Studies: Social Studies of Waste, Pollution, & Externalities* (blog). May 26, 2016. https://discardstudies.com/2016/05/26/anthropocene-adjustments-discarding-the-technosphere/.

Rapp, F. 1981. *Analytical Philosophy of Technology*. Translated by Stanley R. Carpenter and Theodor Langenbruch. Boston Studies in the Philosophy and History of Science. Boston, MA: Reidel Publishing Co. //www.springer.com/gb/book/9789027712219.

Reno, Joshua. 2015. "Waste and Waste Management." *Annual Review of Anthropology* 44 (1): 557–72. https://doi.org/10.1146/annurev-anthro-102214-014146.

Rosol, Christoph, Sara Nelson, and Jürgen Renn. 2017. "Introduction: In the Machine Room of the Anthropocene." *The Anthropocene Review* 4 (1): 2–8. https://doi.org/10.1177/2053019617701165.

Ruddiman, William F. 2013. "The Anthropocene." *Annual Review of Earth and Planetary Sciences* 41 (1): 45–68. https://doi.org/10.1146/annurev-earth-050212-123944.

Samson, Paul R., and David Pitt. 1999. *The Biosphere and Noosphere Reader: Global Environment, Society and Change*. London: Routledge.

Sassen, Saskia. 2014. *Expulsions: Brutality and Complexity in the Global Economy*. Cambridge, Massachusetts: Belknap Press.

Scanlan, John. 2005. *On Garbage*. London: Reaktion Books.

Steffen, Will, Jacques Grinevald, Paul Crutzen, and John McNeill. 2011. "The Anthropocene: Conceptual and Historical Perspectives." *Philosophical Transactions of the Royal Society of London A: Mathematical, Physical and Engineering Sciences* 369 (1938): 842–67. https://doi.org/10.1098/rsta.2010.0327.

Tenner, Edward. 1996. *Why Things Bite Back: Technology and the Revenge of Unintended Consequences*. New York: Alfred A. Knopf.

Thompson, M. 1979. *Rubbish Theory: The Creation and Destruction of Value*. First Edition, First Printing edition. Oxford; New York: Oxford University Press.

Turpin, Etienne, and Valeria Federighi. 2012. "A New Element, a New Force, a New Input: Antonio Stoppani's Anthropozoic." In *Making the Geologic Now*, by Elizabeth Ellsworth and Jamie Kruse, 34–41. Brooklyn, US: Punctum Books. http://ro.uow.edu.au/eispapers/2986.

Verbeek, Peter-Paul. 2005. *What Things Do: Philosophical Reflections on Technology, Agency, And Design*. University Park, PA: Pennsylvania State University Press.

Whiteley, Gillian. 2010. *Junk: Art and the Politics of Trash*. New York: I.B.Tauris.

Winner, Langdon. 2013. "A Future for Philosophy of Technology—Yes, But on Which Planet?" Keynote Lecture presented at the 18th SPT Biannual meeting, Lisbon, Portugal.

———. 2017. "Rebranding the Anthropocene: A Rectification of Names." *Techné: Research in Philosophy and Technology* 21 (2–3): 282–94. https://doi.org/10.5840/techne2017111778.

Zalasiewicz, Jan, Colin N. Waters, Mark Williams, Anthony D. Barnosky, Alejandro Cearreta, Paul Crutzen, Erle Ellis, et al. 2015. "When Did the Anthropocene Begin? A Mid-Twentieth Century Boundary Level Is Stratigraphically Optimal." *Quaternary International*, The Quaternary System and its formal subdivision, 383 (October): 196–203. https://doi.org/10.1016/j.quaint.2014.11.045.

Zalasiewicz, Jan, Mark Williams, Colin N Waters, Anthony D Barnosky, and Peter Haff. 2014. "The Technofossil Record of Humans." *The Anthropocene Review* 1 (1): 34–43. https://doi.org/10.1177/2053019613514953.

Zalasiewicz, Jan, Mark Williams, Colin N. Waters, Anthony D. Barnosky, John Palmesino, Ann-Sofi Rönnskog, Matt Edgeworth, et al. 2017. "Scale and Diversity of the Physical Technosphere: A Geological Perspective." *The Anthropocene Review* 4 (1): 9–22. https://doi.org/10.1177/2053019616677743.

Zwier, J., and V. Blok. 2017. “Saving Earth: Encountering Heidegger’s Philosophy of Technology in the Anthropocene.” *Techné: Research in Philosophy and Technology* 21 (2–3): 222–42.
Zwier, Jochem, Vincent Blok, Pieter Lemmens, and Robert-Jan Geerts. 2015. “The Ideal of a Zero-Waste Humanity: Philosophical Reflections on the Demand for a Bio-Based Economy.” *Journal of Agricultural and Environmental Ethics* 28 (2): 353–74. https://doi.org/10.1007/s10806-015-9538-y.