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It Is Not an Anthropocene; It Is Really the Technocene: Names Matter in Decision Making Under Planetary Crisis

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We do not understand what we see but see what we understand. Words shape the comprehension of our environment and set the space of possibilities we can access when decision making. In here we make the case for the use of Technocene instead of Anthropocene using well-grounded arguments in basic scientific principles. We already know that the Earth system has co-evolved with life phenomena (i.e., the evolution of atmosphere chemistry). What the Technocene idea makes clear is that as modern human societies exhibit an enormous coupling with technology and for the first time in human history that technology has the potential to modify the very core processes that drive Earth System dynamics, then Technology must be considered as a new dimension of analysis in the study of Earth system in its coevolution with life and particularly human beings.

Keywords: anthropocene, planetary crisis, decision making, precautionary principle, Technocene

ANTHROPOCENE, CAPITALOCENE, OR TECHNOCENE?

Ever since the seminal work of Crutzen (2002) where he proposed the Anthropocene concept as a new geological epoch, the concept has become very rapidly mainstream (Malm and Hornborg, 2014). Nonetheless, several critiques have been raised from different approaches. For once, Malm (2016) aims to develop a Marxist account of the planetary crisis, emphasizing the link with development (mainly carbon-centered) and capital accumulation. In the same line of thought, Moore (2016) has posed that beyond a technical geological focus of Anthropocene concept, there is a social reading of the idea developed in terms of the clear increases in scale, scope synchronicity, and rate/speed of environmental change, driven by capital accumulation. So, these scholars suggest that "Capitalocene" is a more historically appropriate term. Others as Haraway (2016a,b) thinks that Anthropocene and Capitalocene are seen as lending themselves too readily to cynicism, defeatism, and self-certain and self-fulfilling predictions. In that sense, the Chthulucene (her proposal), alternatively considers "multispecies stories and practices of becoming-with in times that remain at stake, in precarious times, in which the world is not finished and the sky has not fallen – yet." Then humans are no longer the only relevant actors.

In terms of capital accumulation as a driver of Anthropocene/Capitalocene, we consider that this is only possible by using technologies that allow orders of magnitude more energy extraction (primordially) and other natural resources than before Anthropocene/Capitalocene. In recent work, Burger et al. (2017) have shown that meanwhile, humans organized as hunter-gatherers exhibit an energy flux 10^2–10^3 watts/km^2; energy flux in modern cities ranges from 10^5 to 10^8 watts/km^2 and surpasses global primary productivity on land (10^5 watts/km^2 global average). Without the underlying technology that allowed this energy flux increase, capital accumulation would not have been possible at all, even if wanted. Even more, seeing the environmental trajectory of non-capitalist countries such as China, one may wonder that if the predominant social system would be non-capitalist, does the same or equivalent planetary crisis would have been reached? With regard to Chthulucene, our version of Technocene is based on the Technobiont ontology (López-Corona et al., 2019) that incorporates a multi-species perspective (Holobiont) as well as both biological co-evolution and niche construction, considering genome, symbiont, social and environmental inheritance.

We consider then, that our Technocene construction includes, on the one hand, the main aspects of a historic perspective and some other fundamental concerns of social science, including even some elements relevant from culture and power theorization. On the other hand, it also covers a multi-species non-anthropocentric perspective relevant to the Chthulucene perspective. Nonetheless, it's the greatest strength is the system dynamics perspective as we will develop below.

The concept of Thechnocene is not new as it has been used by anthropologist Alf Hornborg (Hamilton et al., 2015) and the sociologist Martins (2018) whose make a historical and critical review of the role of science in technological development, reviewing the relationship between nature and society from an interdisciplinary perspective. His analysis, which examines the need for political ecology, environmental anthropology and the relationship between science and society, is valuable for understanding different concepts such as the one proposed in this letter from the different disciplines: the Technocene.

We must not lose sight of the fact that this concept is built within the theoretical framework of anthropology. This implies that there is a strong political, social, sociolinguistic, and cultural burden. So approaching the Technocene implies implicitly considering a linguistic approach and therefore lexicon. In this sense, considering the notion of Tecnocene, from this perspective it is worth taking up the reflection of Sen (2019) who suggests reflecting on the appropriate words based on the direct consequences of human reality imposed on the natural and artificial order: "If the first nuclear detonation immediately called to mind the paucity of language to represent reality as awe-inspiring as the mushroom cloud, then the Anthropocene similarly asks us to fashion a new language and expand our vocabulary to bear the weight of our contemporary moment." So it is appropriate to use words that reveal as closely as possible the ontology of the phenomenon.

Which is in accordance with the position of Esposito (2019), because just as an ecocentric approach offers epistemological changes to anthropocentrism, in the same way, a methodology that considers a technocentric approach also suggests to include concepts and notions that allow addressing phenomena of ecological order and social with ontological, epistemological and ethical-political changes.

In this Mini-Review paper, we use the notion of *Technocene* as an environmental concept, in which Environmental Sciences and Earth Sciences converge, and as Hamilton et al. (2015) had pointed out, the post-Cartesian Social Science too. At the same time that interdisciplinary science is intertwined to explain environmental phenomena such as global warming. In this sense, the discussion in the literature about the concept of the Anthropocene is important. For example, from the ecosystem sciences, Malhi (2017) explores the functioning of the biosphere and its interactions with global change; while from a cultural evolution perspective Boyd and Richerson (1996) have studied the development of this geological era. This, without neglecting Haff's vision. Haff (2014) who also proposes six key rules that mediate human beings and technology in the Anthropocene. For us, it is clear that thinking about the concept of *the Anthropocene* is exceeded in the face of technological development and its environmental impact (Cera, 2017). So treating environmental problems and their research from an anthropocentric approach is not adequate. On the other hand, ethical and political problems must be treated in their right dimension (Hensel, 2017), and for this, it is necessary to take into account that we are technological subjects that develop economically on the transformation of nature.

Of particular interest is the work of Peter Haff about how different human technological systems such as communication, transportation, bureaucratic and other systems are interlinked and actually act to metabolize energy (mostly fossil fuels) in a sort of global emergent entity with similarities to the lithosphere, atmosphere, hydrosphere and biosphere. The author calls this the Technosphere, which he considers the defining system of the Anthropocene and most important in the context of the present work, he thinks it is influential and even model what we might consider most intimately and essentially human: our ideas, personal purposes, feelings, and dreams.

In the same sense, a direct antecedent of the importance of niche construction is the seminal work of Herrmann-Pillath who has pointed out how technology co-evolve with other components of human culture such as its institutions in parallel with behavioral and biological evolution, constituting a key element of niche construction. This recognition is incorporated in what we think is a novel ontology, the Ecobiont, discussed in our previous work (López-Corona et al., 2019) and that makes our understanding of Technocene somehow different to previous proposals because is not only about the dominium of technology that enhances the human capacity for niche construction; it is also about the dominium of a new Ecobion, the Technobiont.

A SYSTEMS DYNAMICS APPROACH TO TECHNOCENE CONCEPT

Our approach in this work is based on the recognition that Earth is a complex system, that is maintained in a unique state far from thermodynamic equilibrium through the co-evolution of its biotic and abiotic components by maximizing the entropy production, a process that might be a thermodynamic imperative (Kleidon, 2009; Michaelian, 2012). The Evolution by natural selection considers one direction of this coupling but the other direction, Niche Construction, has been little studied. In previous work (López-Corona et al., 2019) we developed a new ontology, the Ecobiont, to take both directions into account.

The theoretical model for the Ecobiont ontology considers a set of interacting pools: genes (G), microbiome (g), and social (s); that co-evolve from some arbitrary time t to t', through natural selection and niche construction. In contrast to how an abiotic component of the Earth system evolves from a pool of physicochemical components, biological and human systems do it with information stored not only in the genome (physiochemical component) but also in its culture, including technology. To make it clear, it is no longer only a matter of genome or even culture, now it is mainly a matter of how technology modify the evolutionary processes and even Earth System directly (i.e., Climate Change or Ozone Layer Depletion). Then, in order to fully understand the current planetary crisis and make good decisions about how to respond to it, we must be aware of this new extra and key dimension. In our framework, this will lead to a special kind of Ecobiont that captures the existence of human societies extreme coupled with technology. Considering that Burger et al. (2017) have shown that *Homo Sapiens* living in modern cities follow extra-metabolic energy scaling every other mammal do-follow, including hunter-gatherers that we called *Classical Homo Sapiens* (CHS), we proposed that those *Homo Sapiens* living in modern cities are in fact a different type of Ecobiont compared with CHS, we called them: Technobionts (López-Corona et al., 2019). This new (in geological time) Ecobiont type has turned itself into a dynamic driver for earth functioning that has overwhelmed the great forces of nature (Steffen et al., 2007).

Because of the above, here we propose that the Anthropocene new geological era, that is about to get formal recognition, is not the concept we need. For thousands of years, CHS co-existed with the rest of the Earth system's components (biotic and abiotic), so the ongoing Climate or Biodiversity (Dirzo et al., 2014). Crisis are not caused by our human (Anthropic) nature but by an over coupling with some kinds of technologies that enhance unprecedented niche construction capacities. We consider that Technocene responds to the correct source of our current planetary crisis and point out to the proper path, not stop being humans or accepting the catastrophe as Anthropocene would imply, but to find configurations of technologies that take us back to the CHS track as possible, and away from tipping points that could transform the Earth System in an irreversible way (Steffen et al., 2018).

PRECAUTIONARY APPROACHES TO THE TECHNOCENE

For example, in terms of Anthropocene that does not explicitly acknowledge the current key role of technology but only its human origin, a solution to Planetary Crisis may be searched into the technology itself in some sort of red queen process, as not identified as an important component of the problem. This would be similar to trying to resolve antibiotic bacteria resistance problems only by looking for better antibiotics (technological focus) without understanding that abuse in the use of antibiotics (technology) is a big part of the problem. Focusing too much on technological solutions may get us into a never-ending circle of problems made by abuse of technology that is meant to be fixed by using more technology that would lead to new problems (maybe even worst problems). In particular, there has been recent attention to the Big Solutions approach in terms of for example geoengineering, which is regarded by advocates as a creative and responsible technological option in the face of a Climate Crisis (Thiele, 2019). Nevertheless, these calls for emergency geoengineering need to be analyzed with extreme care in a full interdisciplinary or even transdisciplinary manner (Blackstock and Low, 2018) because this kind of re-coupling with new unproven technologies could carry out hidden systemic risk, so Precautionary Principle (PP) should prevail (Taleb et al., 2014). On the other hand, a Technocene perspective could certainly promote technology de-coupling or at least a higher level of technology selection, promoting less invasive ones. For example, in terms of Climate Crisis society could embrace voluntary resignation to certain types of energy use to match sustainable energy budgets like the one promoted by MacKay (2008).

Planetary changes have occurred several times on Earth System, modeling not only its dynamics but also life evolution. Consider the profound impact to Earth System dynamics that came from the emergence of the 3,700-mile planetary scar we know as the East African Rift Valley some eons ago, or how about some 4 million years ago, grasslands began to replace thick forests, and a dramatic pattern emerged in which our ancestors adapted to the unstable environment by the increasingly inventive use of technology and enhanced social cooperation (Dartnell, 2019). Because normally these changes take very long periods, we tend to ignore them from the human perspective, but when talking about planetary-scale technologies these changes could take only a few years.

So, should we be concerned about, for example, the results by Lei et al. (2019) who have shown a suggesting chain of evidence that both ML5.7 and ML5.3 earthquakes from 2018 in Sichuan Province China were induced by nearby Hydraulic Fracking activities? Nevertheless, although these new technologies as fracking should be considered under very high scrutiny, some "old" technologies such as hydraulic engineering, has already proved to have the potential of drive mayor ecosystemic changes. In fact, Williams et al. (2014) identify "Humans as the third evolutionary stage of biosphere engineering of rivers." For the authors, the first two bio-engineering forces are oxygenic photosynthesis and the development of vascular plants with root systems. Then in third place comes human activities such as drainage, agriculture, the construction of artificial water bodies, the development of artificial water storage and flow regulation structures, and some second-order effects as changes in global-scale chemical and biogeochemical modification of terrestrial water bodies (Meybeck, 2003).

Sometimes even small and apparently innocuous technology can add up to produce huge effects, which is the case of human use of chlorofluorocarbons (CFCs) often used in aerosol cans and cooling devices such as fridges, that was demonstrated was the driver of Ozone layer depletion. Discovered using 20 years of ozone levels measurements over the Antarctic stations of Halley and Faraday by Joe Farman, Brian Gardiner, and Jonathan Shanklin, it was published in a foundational paper of 1985 that transformed the fields of atmospheric science and chemical kinetics and led to global changes in environmental policy (Farman et al., 1985; Solomon, 2019). Even "green" technologies could lead to important planetary changes if implemented massively (Kleidon, 2016) as could happen with Eolic energy production that at the end of the day extract kinetic energy out of climatic systems, "Large-scale exploitation of wind energy will inevitably leave an imprint in the atmosphere" (Buchanan, 2011, p. 9).

REMARKS

In that sense, potential awareness induced by recognizing over technological coupling in Technocene or Technobiont concepts could lead to a more precautionary use of some technologies. The Technocene concept is well-grounded into evolutionary and Earth System Dynamics theories, poses a better set mind for decision making and bottom line, we sure cannot stop being *Anthropos* but we may certainly stop being Technobionts. A word of warning here, by no means we are proposing to neglect scientific or technological progress, nor we are thinking we should live as hunter-gatherers. We are merely saying that we need to take technological coupling into account when trying to understand Earth System Dynamics and that some types and intensities of technological coupling should be treated with the maximum application of the non-naive (this is key for not falling into misunderstanding) Precautionary Principle.

As pointed out by Taleb et al. (2014, p. 2), "a non-naive view of the precautionary principle is one in which it is only invoked when necessary, and only to prevent a certain variety of very precisely defined risks based on distinctive probabilistic structures. But, also, in such a view, the PP should never be omitted when needed." For example, in small quantities even controversial technologies as nuclear plants which we know may be prone to catastrophic accidents (Perrow, 1984) don't require to invoke PP. What Charles Perrow notice after his analysis of the Three Mile Island nuclear accident in 1979 is that normal or systemic accidents, often catastrophic, are mainly inevitable in extremely complex systems like nuclear power plants. Nevertheless, even when terrible, the effects of one nuclear plant accident, don't propagate to other nuclear plants and most of the worst damage is local.

In this sense, although it is known that the potential harm due to not only accidents as radiation release or core meltdowns but also by radioactive waste can be large. At the same time, the nature of these risks has been extensively studied, and the risks from local uses of nuclear energy have a scale that is much smaller than global (Taleb et al., 2014). On the other hand, we have geoengineering, an unproven new technology whose potential effects are clearly of a planetary scale and for which we don't have any understanding of direct or indirect risks. Then, to make it very clear, our approach for the use of the Technocene term is not to limit, reject or demonize technology *per se*, but to promote awareness to only some type of technologies depending on their use, type of risk, scale and coupling with other Earth Systems compartments. Very similar to the idea of incorporating the defaunation concept and not only use the established loss of biodiversity. In addition, and maybe a more important perspective is that thinking of Technocene rather than Anthropocene, also opens debate and analysis of philosophical (ontological, ethical), political and social problems about Climate Change and other components of Planetary Crisis, enhancing a deeper integral understanding of it.

Finally, beyond this conclusion around Planetary Crisis and decision making, we consider that Technocene framework highlights the importance of co-evolutionary processes driven not only by natural selection but also niche construction, turning attention to a topic that has not received enough consideration, the great technological acceleration of the past 50 years, and how it has become an Earth System dynamics changer.

It also points to some very interesting theoretical possibilities because bottom line, it might be interpreted as a contextual statistical perspective of Earth System dynamics. Statistical contextually was developed mainly by Khrennikov (2009) as a modification of classical Kolmogorovian probability, that works as a formal framework for systems that are so context-dependent (coupled) that they should not be addressed separated but by an indivisible pair (system, context). In this sense, what we are suggesting is that because the potential planetary impacts modern human societies (over coupled with some technologies) have, any Earth System dynamics description is incomplete without the human technological context.

AUTHOR CONTRIBUTIONS

Both authors contributed to the article and approved the submitted version.

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