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A revisited conceptualization of plastic pollution accumulation in marine environments: Insights from a social ecological economics perspective

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ABSTRACT

The proliferation of synthetic polymer fragments in marine ecosystems has become a prominent issue within recent years, and its disastrous implications on marine species as well as associated social and economic costs have been extensively documented. A narrow perspective of analysis has characterized current conceptualizations of the phenomenon, which is further resembled in the proposed approaches to tackle the problem. Based on a critical realist philosophy of science, this article aims to investigate the fundamental and interdisciplinary dynamics underpinning the current production, consumption and post-consumption lifecycle of plastics, by abstracting transfactual relationships. These then provide the basis to develop a conceptual model for understanding the phenomenon in a more comprehensive manner, and form a framework to assess proposed policy responses for addressing the issue. Thereby the conceptual model draws upon four fields of knowledge: (i) thermodynamic laws and its relevance for economics, (ii) behavioral psychology and resulting limitations of individuals' decision-making under conscious consumer theory, (iii) power theories of political science, and (iv) ethical considerations. The article suggests that ontological and epistemological discrepancies across disciplines, as well as the consequential neglect of several mechanisms have so far limited scientific progress to guide meaningful political action.

1. Introduction

The excessive use of (single use) plastics and its improper disposal have caused plastic pollution in marine environments to become a major ecological challenge within recent years, implying a plethora of environmental, social and economic ramifications [1]. While marine plastic pollution clearly shows properties of being a global interdisciplinary issue, the current academic debate has been characterized by primarily mono-disciplinary applications, focused on very detailed components of the issue. So far, much attention has gone into monitoring and quantifying the abundance of litter, as well as modeling the paths of debris through ocean currents e.g. [2–7]. At the same time natural sciences continuously reveal new evidence concerning the material's negative implications, such as the disclosure of new species that are affected [8–10], or further ramifications for human health [11–13], effects which are more abundant with the accumulated amount increasing [10]. With regards to solutions to the problem, however, natural sciences remain widely ambiguous. From a legal perspective the issue has been examined focusing on the effectiveness of legal institutions and why legal instruments currently in place have allowed for only limited success. Furthermore, the application of legal institutions in local contexts, such as bans on disposable plastic products (e.g. plastic bags), have been subject to scientific investigations [14,15]. Economics' stance towards plastic pollution has been mainly restricted to quantifying the consequences of marine litter [16], and to the study of price adjustments to internalize the social costs of plastics e.g. [17,18], which relies upon market fundamentalism in its approach. Thereby, such analyses presume naive assumptions about societal change, relying upon the tenets of neoclassical economic theories, despite the profound critique that has been addressed towards this perspective to conceptualize anthropogenic ecological issues, and to capture real world dynamics on both micro and macro level [19,20]. Yet, the academic discourse is characterized by the absence of profound interdisciplinary analytical inquiries that aim to better address the interdependencies between economic and ecological systems. While other ecological challenges, such as climate change, have been discussed by heterodox economists e.g. [21], marine plastic pollution has not yet been taken up as a relevant issue.

This paper argues that current conceptualizations of the problem frequently result in reductionist illustrations of the problem, where major mechanisms that constitute a root of the problem tend do be ignored or sidelined to naïve and simplistic explanations. It proposes that ecological economics, and more general, a critical realist philosophy of science represent a more realistic trajectory to analyze the

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issue. The paper further suggests that this reductionism affects the conceptual understanding and in turn influences the proposed approaches to address the problem. Section 2 discusses critical realism and ecological economics as promising frameworks for scientific explorations, and its role in sound interdisciplinary research. Section 3 then raises several concepts from different disciplines that have so far been neglected, before Section 4 draws conclusions.

2. Philosophy of science

2.1. Critical realism

"Scientifically significant generality does not lie on the face of the world, but in the hidden essence of things" [22:217]. While basic assumptions about the philosophy of science underpinning a research endeavor frequently remain implicit, laying them out can countervail the tendency to end up in naïve empiricist explanations [23], which would be incapable of considering the complex dynamics and underlying mechanisms that make up reality [24:42–45]. According to a critical realist philosophy of science, reality is complex, changing, temporal, and exists independently of human consciousness [25]. On an ontological level, three different domains need to be differentiated, namely the 'real' (the underlying structures and mechanisms), the 'actual' (the events and non-events they create and prevent), and the 'empirical' (the experiences that are observable) [22:2]. Thereby critical realism acknowledges that 'real objects' can only be conceptualized as 'thought objects', and thus the theory-laden character of knowledge, as well as the fact that knowledge is always fallible [23].

Following the mode of reductive interference of Danermark et al., this article asks the question "What conditions make X possible?" [25:97], where X represents the phenomenon under investigation. The question of what constitutes the phenomenon (i.e. marine plastic pollution) will be answered by looking at underlying structures and mechanisms. A comprehensive literature review is undertaken to provide the basis for identifying transfactual relationships, which build the foundations for the development of a conceptual model of the current dynamics and mechanisms regarding both plastic production and consumption, as well as its post-consumption dynamics. While a detailed and comprehensive model is not intended (and contradicts the epistemic understanding of critical realism), the model rather aims at incorporating some key mechanisms that represent important prerequisites without which the phenomenon cannot exist.

"Nature is […] a multiplicity of mechanisms jointly producing the course of events. So the course of events is in principle explicable, but not in terms of any one science" [24:46]. Hence, to meaningfully understand these multiple strata (i.e. ordered layers of nature), each of which shows characteristics of emergence, the phenomenon of marine plastic pollution should be looked at from a variety of perspectives, allowing for different disciplinary insights to be acknowledged as relevant parameters of the model. This is specifically relevant, as "[…] disputes between different scientific disciplines regarding the preferential right of explanation appear to result from a lack of understanding of strata and emergence, which is also the reason for the tendency to come up with single-factor explanations" [25:63]. The conceptual model thus aims to understand basic mechanisms of the complex challenge of marine plastic pollution, its origins and implications, by drawing upon concepts and insights across disciplinary boundaries that complement one another to form a more comprehensive model for understanding the very problem.

2.2. Ecological economics

While some appraisals aim to take a multidisciplinary perspective on plastic pollution e.g. [26], they frequently remain uncritical towards the tenets of neoclassical economics. Such analyses then rest upon the triple-bottom-line definition of sustainability, which seems to be a pragmatic ontological explanation, contradictory to the co-evolutionary and emergent dynamics the problem exhibits, and to Passet's [27] concept of embeddedness, wherein economics denotes a sub-system of the social sphere, which is further embedded in the biophysical world. Standard optimization models often assume an idealized and linear functioning of complex coastal and marine ecosystems [28]. Analyses that are based upon such contradictory ontologies with regards to the integration of ecology and economics substantially limit a constructive epistemic undertaking. This underscores the importance of laying open such ontological presuppositions and 'preanalytic visions' see [29]. Thus, to attain a fruitful analysis of nature-economy interactions, a shift in this preanalytic vision (and a differentiated conceptualization of the problem) is required, from one primarily translating ecological meanings into monetary terms, to one that embraces the interrelatedness of ecological and economic systems, and the existence of biophysical limits [30].

A variety of non-economist researchers engaged in the discourse of marine plastic pollution have highlighted the inherent societal and economic nature of the phenomenon and identified the current production, consumption and post-consumption patterns as relevant parameters of the problem e.g. [31–36]. Yet, the role of economics in the discourse has been rather superficial, and restricted to quantifications and monetizations of the implications of marine debris or to cost-benefit analyses, which aim at internalizing costs and improving the functioning of the market [16–18]. This market-fundamentalist approach omits both the critique of the current paradigm to realistically grasp real world challenges, due to its contested axioms of perfectly informed, rationally behaving individuals [37], as well as scientific progress and lessons learned in other ecological challenges, such as climate change or biodiversity loss [21,38].

It has been suggested that the field of ecological economics provides a suitable framework to comprehend evolutionary complexities and govern marine ecosystems [28,30,39]. In general, it has been pointed out that ecological economics can better grasp the interdependencies between ecological, social and economic spheres than prevailing neoclassical theory, and has thus been applied to investigate other issues, where human (economic) activity has been the primary cause of environmental destruction [40]. Ecological economics has emerged from both economics and ecology and is thus distinct from environmental economics, a sub-branch of neoclassical economics, where the rational of equilibrium analysis is applied to environmental issues [41]. Given its interdisciplinary foundation and the acknowledgement of the importance of methodological pluralism,[1] ecological economics has the potential to overcome strict artificial disciplinary boundaries, without contradictions on ontological presuppositions of ecological and economic spheres [42]. This forms a more holistic approach, and one that acknowledges the notion of complex systems, co-evolution, emerging properties, irreducible uncertainties, and the inherent non-linear characteristics of ecological systems [28]. This broad and interdisciplinary approach, integrating social and natural sciences, is required to arrive at a meaningful analysis of ocean governance [30].

3. Multidisciplinary insights for understanding marine plastic pollution

This section raises a variety of key concepts and perspectives from different disciplines, which can meaningfully enrich and broaden the discourse, and present a more accurate picture of the real world dynamics. Specifically, the chapter will look into (i) the implications of biophysical boundaries on the plastics economy, the structure and

[1] Spash [42] has emphasized the importance of a hierarchical philosophy of science (i.e. ontology, epistemology, methodology, methods) to prevent eclecticism, where contradictory elements on an ontological level render a consistent scientific undertaking impossible.

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