

SPACE DEBRIS: LITTER OR POLLUTION?

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Abstract

In this paper, I undertake a conceptual analysis of ordinary usages of the concepts of “litter” and “pollution.” If “litter” or “pollution” applies to space debris in its various contexts, then in dealing with space debris as an ethical concern, we may more neatly apply arguments for the wrongness of litter and pollution to these new contexts. After engaging in a conceptual analysis of “litter” and “pollution,” I consider whether these concepts apply to space debris, examining three contexts: (1) surface debris on Moon and Mars, (2) intentionally crashing objects into gas giants, ice giants, and stars, and (3) the pressing issue of orbital space debris. I conclude by finding that neither “litter” nor “pollution” cleanly applies to any of these three contexts.

Keywords

Space Debris, Environmental Philosophy, Litter, Pollution, Ethics

Resumen

En este artículo, emprendo un análisis conceptual de los usos ordinarios de los conceptos de “basura” y “contaminación”. Si “basura” o “contaminación” se aplican a los desechos espaciales en sus diversos contextos, entonces, al tratar los

desechos espaciales como un problema ético, podremos aplicar con mayor claridad los argumentos sobre la ilicitud de la basura y la contaminación a estos nuevos contextos. Tras realizar un análisis conceptual de la “basura” y la “contaminación”, me planteo si estos conceptos son aplicables a la basura espacial, examinando tres contextos: (1) los desechos superficiales en la Luna y Marte, (2) los objetos estrellados intencionadamente contra gigantes gaseosos, gigantes de hielo y estrellas, y (3) el acuciante problema de los desechos espaciales orbitales. Concluyo concluyendo que ni “basura” ni “contaminación” se aplican claramente a ninguno de estos tres contextos.

Palabras clave

Desechos espaciales, Filosofía medioambiental, Basura, Contaminación, Ética

Introduction

A primary challenge one encounters when applying the tools of environmental philosophy to the context of outer space is its radical difference from our earthly environments; when engaging with the world beyond Earth's atmosphere, things look profoundly different – even where some similarities persist, the scale and material is radically dissimilar. It's easy to lose oneself in the wonders of the universe when looking at other celestial objects, even the ones in our own solar system: basic questions children may ask, such as “what's it like on Jupiter?” lead us in incredible directions. Alien worlds like Jupiter, Mars, or Moon present us with special philosophical problems when approached from the standpoint of environmental ethics by stretching

philosophical and conceptual resources. Anthony Weston makes this point, arguing that some of our concepts may simply not be up to the task of leaving our own atmosphere. Weston asks:

How much of our existing conceptual equipment—how many of our moral and environmental categories—are up to the trip? ...there is a certain “escape velocity” from the conceptual and ethical environment of Earth as well: not an escape from ethics as such—that had better be emphasized right away—but an invitation to rethink everything in a vastly different and larger context. (Weston 2009, 165-166)

The space environment presents a challenge for the project of environmental ethics by straining presuppositions and notions with which philosophers are used to conducting their work. Insofar as language develops for use and successful communication in relation to specific communities, cultures, environments, and ways of life, the alienness of the world beyond Earth is sure to continue to challenge ordinary conceptual resources in surprising ways.

The goal of this paper is to diagnose whether certain concepts, namely those of “litter” and “pollution”, can make the journey to outer space. Approaching space ethics, or astroethics,¹ from the point of view of environmental ethics,

¹ Space ethics and astroethics might be thought of in two distinct ways: first, as an area of “applied” ethics concerned with concrete ethical problems related to space exploration, and so as similar to other applied areas like business ethics, engineering ethics, etc., and second, as an emerging theoretical tradition in ethics. As Milligan and Schwartz note, the area of space ethics emerged out of the advancing activities associated with space exploration, and so its genesis is tied more directly to the applied concerns (Milligan & Schwartz 2023). The theoretical side may, instead, approach space exploration as giving rise to an originary stage of ethical theorizing as posed by Weston (2009), and thereby

it is my intention to explore the applicability of “litter” and “pollution” as environmental concepts to space. Exploring the potential application of these concepts to the issue of space debris may expose where they are limited, further determining where conceptual expansion or generation may be needed for contending with philosophical problems associated with space exploration.

It is taken for granted that littering is wrong – even a paradigmatic wrong for which many may offer environmental reasons to explain. Generally, we also tend to have negative associations with pollution, and may find that polluting acts are morally wrong with reference to environmental reasons. If instances of activity in outer space can be classified as either littering or polluting, then we may apply readymade reasoning to explain the wrongness of those particular actions and their wrong-making features; however, if there are cases where we cannot do so, it appears we will need some innovation in our conceptual or moral resources to deal with them, perhaps through redefinition or the generation of new terminology.

In considering outer space and the application of the concepts of litter and pollution, I will evaluate three distinct contexts of increasing level of challenge to our conceptual resources, and each constituting a kind of “space debris.” The first case concerns the leaving of trash on other celestial bodies with definite surfaces; for example, we have things we have left on both Moon and Mars (Weston 2009; Kilic 2022;

engage with the issues that arise for developing ethical theory and related concepts (see, for example, Lindquist 2022); in this way, the theorizing begins to realize the predicted direction of ethics outlined in Nash’s (1989) *The Rights of Nature*, though one need not maintain that the historical, extensionist project is the proper method for such theorizing (contrast Nash’s idealized and projected history (1989) with Weston’s arguments for a multicentric approach (2004)).

Maki 2022). The second is that of intentionally crashing objects such as probes and satellites into gas and ice giants, such as the outer four planets of our solar system: Jupiter, Saturn, Uranus, and Neptune (See, for example, the ends of both the Cassini and Galileo spacecraft in Siddiqi 2018). The second set of cases may also apply beyond gas and ice giants to stars as well. The third is that of orbital space debris—the debris that sits in orbit around a celestial body—often in the form of defunct satellites, small pieces of metal, flecks of paint, exploded rocket boosters, and other remains from space exploration. As defined in the United States’ *National Orbital Debris Implementation Plan*, “Orbital debris, sometimes referred to as ‘space junk,’ is defined as human-made, non-functional, objects—including fragments and elements thereof—that exist in Earth orbits or are re-entering Earth’s atmosphere” (2022, 7).

In Section II, I will provide a conceptual analysis of litter, pollution, and related concepts (e.g., littering, pollutants, etc.) to make explicit their basic structure for then applying them to the outer space cases. In Section III, I will examine the variety of space contexts listed above, while highlighting historical cases of these sorts of activities, focusing most on the third set of cases. Section IV will serve as a conclusion, summarizing the findings of the preceding analysis.

Conceptual Analysis: A Theory of Litter & Pollution

Curiously, little philosophical literature can be found dealing explicitly with the concept of littering. In some ways, littering may be taken to be such an obvious case of wrongdoing that it needs no in-depth analysis, and as such there does not yet exist a “theory of litter.” However, a much larger focus on pollution as a concept does exist in the philosophical literature, especially related to work on climate

change. In this section, I will provide a comparative analysis of both the concept of litter and the concept of pollution, using paradigmatic cases to tease out some broad conditions for the proper application of these concepts. I do not take the following analysis to be one of trying to distill necessary and sufficient conditions for the proper application of these concepts. The conditions for proper application outlined below are rather common threads among instances of appropriate application of the concepts of litter and pollution in ordinary speech and contexts. Since ordinary language admits of a certain significant degree of imprecision, borderline cases for proper application are to be expected. Thus, judgments of degree and fit need to be applied in difficult cases, and as such, each potential instance of litter or pollution under consideration may not strictly fit the conditions identified below. First, I will consider litter, and then next pollution.

On one hand, we have litter. For litter, consider the following case, which I take to be paradigmatic:

A parent and small child are at a local park. An ice cream truck arrives, and the parent takes the child to get a popsicle. The child, receiving their popsicle, opens the wrapper, drops it on the ground, and begins enjoying their treat. The parent chastises the child for their littering, explaining why littering is wrong and is something that they should not do.

The case itself exemplifies some standard aspects of ordinary littering that one can attend to in exploring the concept. Further, the reasons given by the parent may be investigated for their ability to extend to outer space contexts. The case highlights that litter tends to be a concrete object to which one can point as constituting the litter. Second, litter tends to be localized; it appears to be

more small scale. While it's difficult to say precisely what the boundaries of "localized" or "small scale" are in reference to some ordinary conception of litter, it might be given some rough boundaries in line with ordinary sense perception, thereby being perceptible, or understandable in a scale befitting human comprehend-ability. Another paradigmatic case of litter with these features would be tossing cigarette butts on the ground.

In paradigmatic cases of littering, one can often point to the physical objects of litter, which can also be relatively easily removed, and they appear in a particular place.² Litter tends to take the state of a physical solid in ordinary usage. It might be a stretch of usage to say that someone spraying aerosols in a park (for whatever reason) is littering, or that a boy scout who improperly disposes of some dish soap in the woods is littering. Litter often appears to refer to solids in ordinary usage, allowing for fairly clean ostension (this is also not to say that the aerosol-sprayer or the boy scout are thereby polluting in each case instead). Further, that there are cases where one term – either litter or pollution – applies and the other does not, provides reason to believe that litter is not simply a kind of pollution.

There are at least three common arguments for the wrongness of littering on offer. Some reasons may be better than others and some may only apply under particular ethical

² In considering micro-trash, such as microplastics, etc., i.e., those things that break apart into smaller and smaller pieces rather than decompose into some other substance, it may be noted that they often, though still being perhaps formally solid, appear to us as something more diffuse and dispersed like a gas in the water, rather than as a solid. The diffuseness may play a part in our using the language of plastic *pollution* in the oceans, in addition to the actual negative ecological impacts. So, it appears that litter can *become* pollution, but it isn't so clear that litter and pollution are themselves on a spectrum, such that something can be, say, thirty percent litter and seventy percent pollution.

frameworks; however, it is not my intention here to weigh these against one another to say something definitive about what kinds of reasons are good ones for condemning acts of littering and which are not, as the current analysis is more straightforwardly descriptive about the operation of particular ordinary concepts. The three common types of arguments offered are: (1) possible ecological harm, (2) aesthetics, and (3) viciousness.

First, in terms of possible consequences, one might point to something like the possibility a bird mistaking a discarded bendy straw as a worm and choking on it. Sometimes such concerns are born out in gory reality, such as the number of birds, especially sea birds, found dead with plastic trash left in their bodies (Parker 2015). In such cases, insofar as these concerns rely on broadly consequentialist reasoning, it seems that the litter is made wrong only if it actually harms some animal or other. But further, insofar as the act presents a distinct threat to animals who may not know better, potential for harm is non-negligible – it is, perhaps, too risky to litter as the probability and severity of harm are significant. The objection could also be framed in a more deontic fashion as some duty or other to avoid creating particular kinds of risky situations. The notion of a “potential” for harm, especially in this environmental context, is indeed vague, but I take this to be an emblematic feature of many ordinary concepts, including “potential.” While one could perhaps attempt to further refine the boundaries of something’s having the “potential for ecological harm” as a theoretical development, pinning down the ordinary notion would, I think, be antithetical to the methodological orientation of the current project. At the very least, it seems reasonable to suppose such usages of “potential” have in mind some more temporally proximate possible harms; for example, one may worry more readily about the potential

harm that some littered straw wrapper may cause to some very real bird, not some possible, not-yet-born bird.

Second, broad aesthetic objections to littering may take the character of espousing aesthetic evaluations of environments, whether natural, artificial, or mixed. On more objectivist grounds, beauty (or some other possible, positive aesthetic quality, e.g., majestic-ness, grand-ness, wild-ness, etc.) is worthy of protection, and insofar as littering degrades the positive aesthetic attributes of an environment, it may be taken to be bad or wrong. Such an aesthetic objection to littering is often the type many have against trash along busy roadways, as often these places are liminal spaces and not significant sites of the sort of wildlife people tend to care about; in place of reference to harm done to the other-than-human world, the focus is rather on an aesthetic offense to the observer. Though the objection may be aesthetic in character, the harm, whether primarily conceived of as purely aesthetic or also as partaking in the moral, is mainly referenced in relation to the observer, not the environment itself.

Third, some may argue that there is something vicious about the act of littering (i.e., it expresses that the actor's character is constituted in part by some significant moral vice), providing instead virtue-based reasons for the wrongness of littering. Such attributions may be common upon witnessing an act of littering. For example, the person who throws a paper bag from a fast-food establishment out the window of their car on the highway might be attributed a negative, vicious, character; we may say that such a person is uncaring about the world they live in, uncaring about others, cold-hearted, lacks an appreciation for beauty, etc. Insofar as a virtuous person is one who cares about the natural environment, the environment they live in with others, cares about the wellbeing of others, or cares about

the aesthetic preferences of others (within reason), the vicious character of the litterer represents a vice of deficiency and is thusly objectionable.³

On the other hand, we have pollution. For pollution, consider the following case, which I take to be paradigmatic:

Walking along a lakeshore, in the distance a person sees what appears to be an oil refinery or a factory of some sort. Spewing from smokestacks appears to be some gaseous mixture. Such a mixture likely contains carbon dioxide, a known greenhouse gas that contributes to global anthropogenic climate change.

It would seem odd to say in such a case that the factory or refinery participates in the act of littering. Corporate/industrial cases of pollution, whether instances of corporations intentionally dumping waste products into rivers, or more accidental instances of fertilizer runoff into nearby waterways, seem to also be paradigmatic cases.

³ Littering is presented in literature in a multitude of ways, especially in environmentally oriented pieces, such as *Sick Puppy* by Carl Hiassen (2000) and *The Monkey Wrench Gang* by Edward Abbey (1976). In Hiassen's book, the plot is jumpstarted by the main character's vindictiveness against a highway litterer, initiating the outrageous series of events and ecotage (or monkeywrenching) typical of many of Hiassen's novels. In Abbey's book, one of the main characters engaged in the direct action within the plot, George Washington Hayduke, litters constantly, throwing beer cans out the window of his car all along the highway. Such behavior appears starkly at odds with the ethos of the group and what we typically take pro-environment actors to be like. As has been previously explored by Trumpeter (2021), littering can take on the character of the action of an activist according to Abbey, holding that the litter contributes to and highlights the ugliness of a stretch of highway. Trumpeter (ibid.) also comments on litter and biodegradability in Ernest Callenbach's *Ecotopia* (1975), though such visions may, in more wild contexts, echo complaints of fruit peels left by previous hikers along trails (see, for example, Castrodale 2019).

Looking at more personal cases of pollution, it makes more sense to claim that the greenhouse gas emissions from one's car constitute pollution and polluting, than it does litter or littering.

So, what are some commonalities between various instances of pollution? For one, the object of pollution appears to be gaseous or liquid in terms of its phase of matter (more modestly, pollution/pollutants are, generally, non-solid in their perceived character). Due to a lack of perceived solidity, pollution and pollutants appear to be more commonly spatially dispersed; as such, while one can sometimes point to the source of pollution, as in the factory or oil refinery case (even the name of a particular classification of pollution is "point-source pollution"⁴), the actual pollutant has a particular dispersal to it that may make it more difficult for clear ostension. The perceived ethereal nature of the substance of pollution/pollutants is further highlighted by the ever-increasing kinds of pollution identified by environmental scientists and activists, such that alongside pollutants like anthropogenic greenhouse gasses, light pollution and noise pollution are garnering more attention (both light and noise would likely be intuitively characterized as non-solid, though not formally gaseous).⁵ Pollution also appears to be further dispersed in its effects, i.e., it may not be localized (or as localized) compared with

⁴ The United States Environmental Protection Agency clarifies "point source" pollution: "The term 'point source' means any discernible, confined and discrete conveyance, including but not limited to any pipe, ditch, channel, tunnel, conduit, well, discrete fissure, container, rolling stock, concentrated animal feeding operation, or vessel or other floating craft, from which pollutants are or may be discharged" (2022).

⁵ As we come to better understand animal olfaction and the chemosenses more generally, it is possible that we may also find olfactory pollution of environments to be a further problem negatively affecting wildlife. For some discussion, see Lindquist 2023.

litter. The negative effects of certain pollutants extend globally; excessive greenhouse gas emissions (in both quantity and rate of production) impact the climate; what's dumped into a river ultimately flows downstream into other bodies of water; light and noise extend atmospherically with difficult to discern boundaries, locations, or discrete objects. Due to the apparent messier nature of gasses, liquids, and non-solids more generally, the effects of pollution are often highlighted more clearly than the pollutants themselves. Effect areas of pollution are larger and more dispersed, causing actual negative environmental effects rather than merely possible ones associated with some of the potential wrong-making reasons offered against a particular act of littering. Furthermore, the negative ecological impact appears to be a weighty component of the concept of pollution; an anthropogenically introduced liquid or gas, absent negative effects, would not be considered pollution. A negative environmental impact of some kind or other might approach something like a necessary, though not sufficient condition for something to be pollution; negative ecological impacts may extend to litter as well, including death, as mentioned above with seabirds (Parker 2015).⁶

As Aaron Lercher (2004) points out, blameworthiness for pollution is complicated, but may be further elucidated through comparisons with litter. We almost always think of littering as blameworthy and something to be avoided if possible, odd fringe cases aside. Pollution, especially when considering individual actions and the scale of effect of pollution-based problems, complicates simple ascriptions of blameworthiness. For much of individual pollution,

⁶ Consider, for example, dumping a thimble of clean water with no significant difference in temperature into a river. The quantity could be extended somewhat as well, but it would seem odd to classify such an act as one of pollution since no ecological harm would result from it.

individuals may be constrained by situational factors wherein consequentialist-style cost-benefit analyses play a significant role. Lercher presents the ordinary example of driving to work, which Lercher identifies as a “polluting act,”⁷ wherein there are particular pollution costs and benefits to driving to work (e.g., driving causes exhaust and carbon dioxide emissions, but I also get where I want to go) and particular situational factors may play into blameworthiness in each case (e.g., whether the driver is negligent in some significant regard, etc.) (ibid.).⁸

⁷ Lercher (2004) defines a “polluting act” as “an act (‘making something happen,’ however that may be understood) such that there are externalized costs that are widely scattered” (408). For Lercher, the scope of a polluting act is thus tied to externalized costs, and so extends to things that likely would count as odd instances of pollution to many people, such as the danger posed to drivers of smaller cars by those who drive larger cars. Since Lercher’s project is not concerned with attempting to reveal some folk, intuitive, or ordinary concept of pollution, but rather develops the notion of a polluting act for the purposes of exploring blameworthiness, the differences in our analyses are not imperative.

⁸ Cases like driving are unique in comparison to something like the larger carbon footprint discourses. With driving, the driver appears to be more directly related to the polluting act. When considering pollution generated through supply chains, for example, the greenhouse gas emissions associated with meat eating or the methane emissions from rice production, the blameworthiness of the consumer for the requisite emissions is a messy matter. I do not intend to generate a solution or commentary on the ethics of such things herein, as my goal is much more conceptual in looking rather at patterns or kinds of reasoning applied to litter and pollution for then exploring the issue of space debris in different contexts. The point here is that in looking at pollution, we have both individual and institutional instances, but we might justifiably think about blameworthiness for the effects of pollution as applying differently to these different cases, scaled to the polluting entity and the countervailing reasons or justifications for such polluting acts.

Summarizing the results of the above analysis, ordinary conceptions of litter and pollution may thus be compared using the following chart to assist with further analysis:

| Litter | Pollution |
|---|---|
| (1L) Solid, discrete object; easy ostension | (1P) Liquid or gaseous (non-solid); difficult ostension |
| (2L) Localized; small in scale | (2P) Dispersed; large in scale |
| (3L) Reference to potential eco-harm | (3P) Reference to actual harm or eco-problem |

Space Debris: Litter, Pollution, or Something Else?

For analyzing the application of the concepts of litter and pollution to outer space contexts, I will consider three potential cases of human-generated waste in outer space. The first case is that of leaving trash on other celestial bodies with definite surfaces, such as discarded experiments on Moon, dead Mars rovers, or even debris from Mars landing operations (Weston 2009; Kilic 2022; Maki 2022).⁹ The second case is that of intentionally crashing objects such as probes and satellites into gas and ice giants; for example, crashing the Cassini spacecraft into Saturn and the Galileo spacecraft into Jupiter (Siddiqi 2018). The third case is that of orbital space debris. To reiterate, the goal of this paper is to assess the conceptual extension and application of “litter” and “pollution” to outer space contexts, and so straightforward ethical analyses about whether leaving such debris in particular places is actually morally wrong or blameworthy is auxiliary to my analysis herein, though the potential reasons on offer are not.

⁹ For example, Cagri Kilic estimates there is about “15,694 pounds (7.119 kg) of human debris on Mars” (2022).

First, consider case one, that of surface debris on celestial objects with definite surfaces. Surface debris on Moon and Mars is much more akin to our regular Earthly contexts in part because such cases more closely resemble the phenomenological orientation provided by planetary gravity. In other words, in each context one can “stand on” some celestial body. When first considering the concept of pollution, insofar as pollution is often liquid or gas and therefore difficult to point at (condition (1P)) because of the dispersal of such substances (condition (2P)), it appears that the debris on such surfaces does not fit the notion of pollution outlined in the previous section. Furthermore, if pollution has a strong tie to having a negative environmental or ecological impact (condition (3P)) it does not appear that such waste on Moon or Mars constitutes pollution. If negative environmental or ecological impact of debris is a weighty condition for being pollution, insofar as the ecological necessitates life, pollution seems to not apply to these contexts insofar as they are lifeless.¹⁰

¹⁰ The biocentric biases of much of environmental ethics often stumbles when applied to outer space environments, and so shedding these biases are often an important step in adapting much of environmental ethics to them (Schwartz 2019b; Lindquist 2022). As an anonymous reviewer notes, one may think that we could pollute even a lifeless environment through pumping smoke into its atmosphere or dumping radioactive material on it. Regarding whether adding various gasses to the atmosphere of a lifeless planet would constitute pollution, it would depend on their relation to some ecological harm; as such, we would likely still make reference to biotic organisms and their respective goods. For example, compare instances where the introduction of gasses is helpful to some terraforming project to those wherein the gasses would inhibit some settlement project. In those instances where gas introduction is for terraforming purposes, the language of pollution would likely not apply since there's no strictly *ecological*/harm being done – in fact, the acquisition of classical ecological goods like biodiversity becomes more achievable. In those instances where gas introduction

Unlike pollution, litter might apply more readily to this first case. Many of the objects are solid: string, heat shields, pieces of metal, etc. (condition (1L)); they may also be positively identified and able to be pointed to (condition (1L)); they can also be localized, though places with some atmospheric dynamics, such as Mars, might move objects and somewhat more widely disperse debris from their initial point of placement (condition (2L)). Ecological harm (condition (3L)) is not really referred to in the case of Lunar or Martian trash in part because, without life, there is no real ecology to speak of. Objections to Martian littering may still appeal to similar reasons as those for Earthly litter; one could reasonably object with appeal to aesthetic reasons or in reference to the viciousness of the actors in such cases, whether individual or institutional.¹¹ So, it appears to make sense to refer to the objects on Moon and Mars as appropriately constituting litter, though such instances failing condition (3L) may be reason to doubt a conclusive designation as litter. Furthermore, litterers on Moon, Mars, and other celestial objects are perhaps better described in terms of more abstract, social, institutional entities, thus

may further preclude human settlement and flourishing, the language of pollution may begin to apply in reference to human capabilities for living and thriving. Dangerously radioactive materials present a more difficult case, even in thinking of the forms of matter (the materials themselves may be solids, but the radiation itself may stretch our classifications, so a more thorough analysis of radioactive waste may be needed separately).

¹¹ In reference to the question of terraforming, Sean McMahon (2016) presents an aesthetics-based objection, which could likely be put to the task of critiquing Lunar or Martian litter as well. Also, within the terraforming literature, Keekok Lee's (1994) approach which highlights awe and humility, as well as Robert Sparrow's (1999) virtue ethics objection, could also levy critiques of littering celestial bodies. Environmental virtue ethics is a growing area, but the resources provided by Thomas Hill Jr. (1983) may also help to elucidate an objection here.

diverging somewhat from paradigmatic cases described in the previous section, referencing state-based space programs or corporations instead of the typical individual actor.^{12, 13}

Second, consider case two, that of intentional crashing into gas giants, ice giants, and other celestial objects without “proper” grounds to stand on, such as stars. Two of the more famous examples of intentional crashing into these objects is that of the controlled crash of the Galileo orbiter into Jupiter in 2003 and the Cassini orbiter into Saturn in 2017, both at the end of their research journeys. The seemingly necessary condition of negative environmental or ecological impacts for something to be properly considered pollution or a pollutant appear to not hold for such cases (Condition (3P)). Further, it’s not clear that litter could apply neatly as, while the orbiters themselves are discrete, ordinary physical objects, the resultant matter that likely results from the pressure and heat of these celestial objects would render solid objects dispersed as liquid or gas (Objects that may

¹² It is possible that the lack of philosophical reflection and theorizing on litter is due to its often being rooted in individual action, and a rather smaller problem compared to more existential concerns like greenhouse gasses and anthropogenic climate change. There are bigger fish to fry, so to speak, than litter.

¹³ As an anonymous reviewer has pointed out, some more ordinary instances of littering may be the result of larger social entities. In the case of surface space debris on Moon, it may be more properly attributable to NASA than any individual astronaut – for a stronger case, the litter from landing rovers on Mars involves no particular individual litterer. While I take it to be the case that paradigm cases of litter are more strongly related to individual actors and paradigm cases of pollution are more strongly related to larger social entities, this is not to preclude individuals polluting or social entities from littering. But the philosophical tools of environmental philosophy surrounding pollution would need to be brought to bear on materials of a different sort with litter – whether this particular extension may be done cleanly or not, requires further investigation.

meet condition (1L) and (2L), through their entry into the celestial object, transform them such that the resultant materials more aptly meet (1P) and (2P)). We might, in a way, compare these celestial objects to gigantic waste incinerators in our solar system. The outpouring of gasses from waste incinerators on Earth qualifies as pollution due to their negative impact on environments/ecosystems and life, both human and other-than-human. Orbiters that crash into Saturn, Jupiter, stars, etc. likely have no similar effect that could be pointed to that would qualify them as pollutants or pollution (Condition (3P)). While crashing such orbiters into these kinds of celestial bodies may not be qualified as litter or pollution, litter and pollution are not the only wrongs one can commit, let alone the only environmental wrongs. One could perhaps still object to such intentional crashings on various moral grounds, whether virtue, deontic, or otherwise, but such objections seemingly cannot appropriately refer to ordinary conceptions of litter and pollution.

Third, consider case three, orbital debris. Before proceeding with an examination of the issue of orbital debris in relation to the concepts of litter and pollution, a contextualization of the issue of orbital debris generally may assist with a more appropriate overall analysis. What is it about near-Earth orbital debris that makes it an issue worth concerning ourselves with? Space debris has accumulated in orbit around Earth from rocket launches, satellites becoming defunct, and collisions between objects in orbit; tests of anti-satellite weapons have also produced further space debris. Although orbital debris sometimes burns up in the atmosphere upon reentry, sometimes it does not. Take the 1978 case of Kosmos 954 for example, a Soviet intelligence satellite that reentered Earth's atmosphere, scattering debris over 30,000 square miles of land in the

Great Slave Lake region of Canada – of special note in the case of Kosmos 954 is that due to its Uranium reactor, there was a real risk of the debris being radioactive (Power & Keeling 2018; Hunter & Nelson 2021).¹⁴ Debris, especially radioactive debris such as that from the Kosmos 954 event, poses a much more straightforward problem for people and environments affected by such waste.¹⁵

The speed and quantity of space debris presents future challenges for putting more objects in orbit.¹⁶ Debris can accumulate, and it's theorized that a potential debris cascade could result in negative consequences for future space exploration. Referred to as “Kessler Syndrome,” it constitutes “a collision cascade in which pieces of space debris begin to collide and break into smaller pieces, eventually creating a cloud of debris around Earth that makes access to space too risky, uneconomical, or even impossible” (Green 2022, 69). A Kessler syndrome cascade may thus trap humanity on Earth unless something could be done to clean up Earth's orbital environment. Kessler's original paper, written with Burton Cour-Palais, was

¹⁴ Hunter and Nelson (2021) provide some important commentary on the Kosmos 954 disaster and its aftermath, highlighting the effects of the debris distribution and radioactive material on the Dene and Métis peoples living on the affected land, as well as inequities and injustices related to the Canadian cleanup efforts.

¹⁵ The individual pieces of debris that crashed could be considered as a kind of unintentional litter, while the radioactive material could be said to have a polluting effect. Nuclear waste and radiation present an interesting case for further theorizing about litter and pollution.

¹⁶ The velocity of orbital space debris can be measured in terms of kilometers-per-second. As Brian Patrick Green recounts in his *Space Ethics* (2022), in 1983 a fleck of paint estimated to be 0.2mm hit a window of NASA's *Challenger* space shuttle, necessitating a replacement. It was estimated that the damage caused was consistent with the paint fleck moving between three and six kilometers per second (68) (See also Kessler 1986, 57).

published in 1978, and since then the amount of orbital debris has only increased. If we have obligations that require the extension of humanity beyond Earth, whether to expand our knowledge of the cosmos (see, for example, Schwartz 2011; 2019a; 2020) or settle other planets to ensure the survival of humanity (see, for example, Abney 2019) or other Earth-based life forms, Kessler syndrome may lock us on Earth, frustrating these obligations and their requisite goods.¹⁷

Attempts at rectifying issues of orbital space debris have tended towards preventing the creation of more debris rather than cleaning up existing debris. Cleaning up space debris presents the additional problem of dual-use technology, defined by Green (2022) as “a power or technology that can have both good, beneficial uses and bad, harmful uses” (264). Technology that could be used to clean up space debris could also be used against orbital technologies of others (Green 2022, 78) while also posing a threat to the stability of the Outer Space Treaty (United Nations General Assembly 1966). While spacefaring states and corporations could avoid creating more space debris, debris may nevertheless increase because of collisions between space debris already in orbit. If space exploration activities are to continue, something might need to be done to clean up what orbital space debris already exists. As collisions increase, so does the quantity of debris, though much of it thereby becomes smaller. One Earthly analog to the space debris problem, often used as a point of comparison, is that of the great Pacific garbage patch (see, for example, Kluger 2023). Insofar as the plastic issue in the ocean tends not towards the breakdown of plastics but

¹⁷This is, of course, a problem particular to those who argue that we have such obligations. In this paper I do not commit to any particular view as to whether we actually have these obligations.

rather towards their merely becoming smaller and smaller – microplastics – the comparison is at least apt in this regard; smaller pieces of debris in orbit are, like microplastics, likely more difficult to remove.

So, is orbital space debris closer to being litter, pollution, or something else? In June of 1985, the University of Georgia hosted what might have been the first (if not one of the first) conferences explicitly on philosophy and space exploration. Organized by Eugene C. Hargrove with funding from the Program on Ethics and Values in Science and Technology of the National Science Foundation, the conference was entitled “Environmental Ethics and the Solar System.” The conference culminated in the publication of the collection *Beyond Spaceship Earth: Environmental Ethics and the Solar System* (Hargrove 1986), which includes a chapter by Donald Kessler entitled “Earth Orbital Pollution” (1986). The title of Kessler’s piece stands out from much of the other work on the subject that appears to attempt to avoid language of either litter or pollution, opting instead for the more neutral, sterile language of “debris.” In fact, though “pollution” is in the title of Kessler’s 1986 piece, the term makes no appearance in the text of the chapter. “Litter” also makes no appearance.¹⁸ A survey of the literature on space debris appears to make no commitments regarding space debris being litter or pollution, so the issue of its status is open.

First, consider the case for orbital space debris as litter. For one, much of it is certainly solid, though a sizable amount of it is very small (and moving very fast). It thus makes sense to say that orbital space debris often consists of

¹⁸ While an extensive corpus analysis of work on issues of space debris does not exist, at least to my knowledge, a brief survey of literature on the topic reveals the use of “debris” more commonly than any notion of “litter” or “pollution,” if those terms or concepts appear at all.

solid, discrete objects that may be more easily pointed to (Condition (1L)). One thing the orbital space debris problem is not is small in scale or localized. Sure, orbital space debris is indeed small in scale and localized in the grand scheme of the expanse that is the cosmos, but relative to Earth the problem is potentially, catastrophically all-encompassing. Compared to those things that often are called litter (e.g., the popsicle wrapper in the park), orbital space debris exists on a much more massive scale, such that referring to it as being localized or small in scale appears to be a misrepresentation, thus space debris fails to meet condition (2L). Discourse surrounding orbital space debris does often make reference to potential ecological harm in attempting to explain its potential wrongness, whether in terms of a Kessler syndrome cascade ensuring the extinction of the Earthly tree of life or in terms of the possibility of debris falling to Earth with grave consequences (Condition (3L)). So, as far as considering space debris to be litter, it satisfies conditions (1L) and (3L), consisting of solid discrete objects and constituting a threat to some ecological entity or good, while failing condition (2L), since it is large in scale and not localized.

Second, consider the case for orbital space debris as pollution. Orbital space debris, in being primarily solid, fails to satisfy condition (1P). For the reasons orbital space debris fails to meet condition (2L), it appears it would satisfy condition (2P); orbital space debris is not localized, but rather quite dispersed. Things become more complicated when assessing whether orbital space debris satisfies condition (3P). One may reasonably ask what ecological harm orbital space debris does while in orbit. Further, one might even ask whether orbital space even constitutes an ecology that could suffer ecological harm. It certainly interacts with Earth and affects Earth, and the activities of

living beings on Earth certainly affect it (e.g., rocket launches), yet there is no life in orbit besides that which humans put there (whether, human, dog, plant, or microbe), often in places like the International Space Station (which occasionally needs to take precautions for space debris (Kluger 2023)). Still, we might think that while there are some living beings in orbit around Earth, they are so cut off from biological interaction with the orbital space outside of their vessels that it might be odd to say that their being in orbit *makes* orbital space an ecosystem.

So, why separate the space environment, or at least the orbital space environment, from some larger ecological whole that includes the Earth, the Sun, etc.? Weston challenges classical thinking about the boundaries of “the environment,” writing:

Normally we picture “environment” as terrestrial, as the region of Earth’s surface and what lies close beneath and above it... “Environment” does not end at the surface of the Earth. But then why suppose it ends at all? Of course there are always various provisional boundaries, much as one ecosystem can be distinguished from neighboring ones—but no absolute boundary. Ultimately we are coming to understand that all terrestrial ecosystems are linked into a greater and quite dynamic whole. By analogy, space exploration is now challenging us to recognize that the “terrestrial” may not be a closed system either. (Weston 2009, 167–168)

One potential response for considering the orbital environment as separable in some way from a larger cosmic environment, or from terrestrial Earth, is to further specify the type of thing being talked about. “Environment” is often too general a term and, often, refers only to the space which

things inhabit, often living things. Following Lindquist (2022), one might instead talk about a “four-dimensional spacetime region that includes dynamic systems activity exemplified by geological, atmospheric, or hydrological processes that are made manifest in their partially determining the character of a place or environment” (242). This language indicates that the environmental character of the orbital environment may be different than that of Earth; these distinctions could be made even more fine-grained, as Earth consists of many spaces that meet Lindquist’s conditions while manifesting different environmental characters, thus a distinction may be drawn denoting the orbital environment as sufficiently separate. While this language avoids the biotic necessary conditions of ecosystem language, if pollution necessitates there being an ecological harm, and the ecological necessitates the biological, then it also precludes much of the outer space environment from being polluted; therefore, the orbital space environment would fail to meet condition (3P). Notably, however, the Kosmos 954 tragedy presents a challenge. While Kosmos 954 was in orbit, even if it were defunct, it would not constitute pollution, but its effects upon reentry and breakup, including dispersing radioactive material, would indeed constitute pollution. So even if orbital space debris does not constitute pollution in orbit, it may attain such a classification upon reentry if it has negative ecological effects; further, not being pollution while in orbit is not sufficient reason to disregard it or its potential negative effects, both in orbit and upon reentry.

In summary thus far, considering orbital space debris as litter, it meets conditions (1L) and (3L), but not (2L), and as pollution it meets condition (2P) but not (1P) or (3P). Initially, a classification of orbital space debris as litter instead of pollution may be sensible since it meets two

criteria for litter and only one for pollution; however, orbital space debris fails condition (2L) in *spectacular* fashion, as it is incredibly diffuse, thus providing cause for doubt about the litter classification. Further, if paradigmatic cases of littering are carried out by individual actors and orbital space debris comes about instead as a result of institutional entities, then the case of orbital space debris diverges from the paradigmatic cases of littering in yet another way (though this is not to preclude the very real possibility of individual actors littering in orbit as well). Approaching orbital space debris with a framework aimed at individual actors when the problem arises instead from institutional entities may thereby constitute a mistake.

As mentioned in Section II, classic arguments against littering may reference potential ecological harm, offering aesthetic considerations, or reflecting on the vicious character of the litterer. To address issues of potential ecological harm, perhaps regulation could be enacted to prevent the perpetuation of the problem that is orbital space debris. While states could regulate to avoid the creation of unduly risky situations in the first place, finding the creation of certain sorts of risky situations morally problematic, such an approach faces issues of attempting to calculate and weigh probabilities of harm actualizing and the severity of harm that may be incurred – the details would need to be filled out, and the details matter. This more deontic framing could also be applied to the popsicle wrapper litter case presented in Section II, so a framing surrounding risk aversion could still be helpful and apply easily to state and corporate actors (though, of course, determining the legislation would come with many practical difficulties).

Aesthetic considerations regarding orbital space debris are perhaps temporally far off due to the distribution and small size of much current space debris; were space

debris to begin to significantly affect the night sky, then perhaps this objection could carry more weight, though such an objection may already be able to be levied at some orbital objects like satellites.¹⁹

References to vicious character become more complicated in having to ascribe character to institutions, corporations, and governments, rather than individual people; these issues become even messier in current political contexts as we also perhaps ask whether governments or for-profit corporate entities could ever even be virtuous, or if by their very nature they are thereby vicious (i.e., by learning and practicing virtue, they would cease to be the sorts of entities that they currently are, thereby simply ceasing to be).

More complicated moral and political analyses are needed to deal with the actors in the case of would-be litter at this scale, such that the regular frameworks are stretched perhaps beyond their normal operating conditions. The conditions for assessment and altering the behaviors of the would-be celestial litterbugs are, in some significant ways, unlike paradigmatic cases of littering. While orbital space debris is closer to litter than pollution, the sorts of resources needed to engage with it are those developed in the context of discussions about pollution. Such recourse thus may cast

¹⁹ There are also concerns about losing dark skies and the impacts of such a loss aesthetically, as a loss of potential transformative experiences, as a negative health impact, ecological harm, etc. Dill (2022), commenting on dark skies and light pollution, explores the negative health impacts for humans and other species, as well as how light pollution may impact the reproduction and navigation of nocturnal species. Dark skies now have international advocacy groups such as DarkSky International. It's also possible that increases in satellites could present a problem as well for not only dark skies but Earth-based life, and perhaps a more serious one if skies become darker through successive victories of dark sky activists, for if skies become darker, more satellites may thus be made more perceptible, and so their effects may then become more pronounced.

doubt on the status of orbital space debris as litter, leaving the problem in an odd sort of middle between being conceptually litter and pollution, consisting of parts of both but winding up neither in the process. While we may have some philosophical resources to levy at the problem, straightforward appeals to associated ordinary concepts of litter or pollution will not aptly apply to the situation at hand regarding orbital space debris, thus these ordinary concepts lack the requisite escape velocity to apply to at least some outer space contexts as they currently stand.

Conclusion

Following Anthony Weston's (2009) challenge, do the concepts of "litter" and "pollution" achieve escape velocity and apply to outer space contexts in a clean way to be helpful in moral deliberations about space debris? Not entirely. In the context of space debris on the surfaces of other celestial objects like Moon and Mars, the concept of litter appears to apply, but how we might engage in ethical discourse about the problem would primarily be with the tools of pollution discourse since the entities involved are often state or corporate actors instead of individuals. In the context of space debris as objects crashing into gas giants, ice giants, or stars, neither litter nor pollution appears to apply, and so will not serve any use in moral discourse. In the context of orbital space debris, while it may appear to be litter, we are still faced with it not being localized but rather radically dispersed, which strains the use of the ordinary concept of litter in this context even further, perhaps radically so. The outer space context thus appears to present us with some

new problems and is thus not reducible to a mere iteration of some other environmental problem.²⁰

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²⁰ A common line of argument often appears when new problems are proposed, which points out that some supposed new problem is really just the same as some older problem and is not *really* providing anything significant or new to deal with. For examples of this kind of argument, see Preston 2013 on synthetic biology and Katz 2022 on de-extinction technology.

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