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Near-Earth water sources: Ethics and fairness ☆

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Abstract

There is a small finite upper bound on the amount of easily accessible water in near-Earth space, including water from C-type NEAs and permanently shadowed lunar craters. Recent estimates put this total at about 3.7×10^{12} kg. Given the non-renewable nature of this resource, we should begin thinking carefully about the regulation of near-Earth water sources (NEWS). This paper discusses this issue from an ethical vantage point, and argues that for the foreseeable future, the scientific use of NEWS should be prioritized over other potential uses of NEWS.

Keywords: Lunar resources; Asteroid resources; Water; Ethics; Space policy

1. Introduction

According to a widely promulgated vision, the space environment offers a cornucopia of resources, the utilization of which will help free us from the kinds of destructive resource depletion that threaten our long-term well-being here on Earth. The author has argued in other work (Schwartz and Milligan, in preparation) that, at least as far as near-Earth space is concerned, this vision is misguided. Although there is in-principle a large supply of useful resources, our access to them is limited by a variety of physical and practical constraints. Any especially valuable resources which might be exploited for terrestrial consumption, e.g., platinum-group metals, are only likely to arrive in a slow, staggered trickle. Thus, the exploitation of the resources of the moon and NEAs is unlikely to eliminate terrestrial scarcity anytime soon, if ever. The upshot is that regulation of near-Earth resource exploitation must include measures to ensure the sustainability of these scarce resources.

This paper considers the policy implications specifically for the exploitation of water in near-Earth space. Although (and for good reason) seldom of interest for its terrestrial uses, nevertheless water is a further example of the claim that near-Earth space is resource poor. Recent estimates of the water potentially available from lunar polar craters and from NEAs total to about 3% of the volume of Lake Nicaragua. Given the scarce and non-renewable nature of this water supply, the author argues that any regulatory framework for near-Earth water sources (NEWS) must aim to ensure more than mere *equitable access* to NEWS—regulation moreover must actively appraise of the overall *ethical value* of exploitation proposals so as not to lead to a situation in which this scarce resource is wasted on trivial or frivolous objectives.

☆ Based on a presentation delivered at the 2nd COSPAR Symposium, Water and Life in the Universe, November 2015, Foz do Iguaçu, Brazil. The author thanks those in attendance for discussion and comments. Several of the ideas in this paper were contemporaneously developed by the author in a joint contribution with Tony Milligan, "Some Ethical Constraints on Near-Earth Resource Exploitation" (in preparation in a future volume of *Yearbook on Space Policy*), which considers the policy implications of near-Earth resource use more generally. Thanks to Tony Milligan and Colin McInnes for discussion, and to an anonymous referee at *Advances in Space Research* for helpful suggestions.

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2. Water near Earth

Aside from Earth itself, there are two major water sources in near-Earth space. These are:

- Water potentially available in permanently-shadowed craters on the lunar poles; and
- water available in the NEA population, primarily from C-type asteroids.

Though alternative NEWS exist, these two represent the most attractive sources from an energy perspective, and thus the most likely sources of exploitation in the absence of distant, futuristic technology. How much water are they likely to contain?

On the lunar surface there is somewhat greater than 31,000 km^2 of permanently shadowed area (McGovern et al., 2013). If the entirety of this surface contains water ice at the concentrations measured by LCROSS, then we should expect there to be approximately 2.9×10^{12} kg of water ice in permanently shadowed craters ([p. 146] Crawford, 2015). Although this is a considerable quantity of water when considered in isolation, nevertheless it is very meager when compared to many freshwater lakes on Earth. For instance, this quantity amounts to approximately 0.013% (by volume) of the water in the Great Lakes, or slightly less than 3% (by volume) of the water in Lake Nicaragua.

Water in the NEA population needs to be considered somewhat more carefully. Here the problem is not so much an estimation of the total quantity of water in the NEA population but rather the total quantity of *accessible* water. The simple fact is that not every asteroid is an attractive mining candidate. Many require too much energy to intercept, capture, and return to cislunar space; many are too small to justify mission costs; etc.[1] Moreover, the asteroid must be of the appropriate type for water extraction—principally C-type.

A reasonable benchmark for energy costs would be the energy required for lunar escape—thus a Δv value of approximately 2.37 km/s for the return trip. At this energy cost there is on the order of 10^{14} kg total of asteroid material accessible ([p. 447]Sanchez and McInnes, 2013). Sanchez and McInnes estimate that C-type asteroids comprise 10% of the NEA population, and that we should expect these asteroids to contain, on average, 8% water by mass ([p. 454]Sanchez and McInnes, 2013). According to these estimates, then, we should expect there to be somewhere around 8×10^{11} kg of water that can be returned to cislunar space at lunar escape velocity—a significantly smaller quantity of water than is potentially available on the lunar surface. When these quantities are added together, the total quantity of water that can be accessed in near-Earth space comes to only about 3.2% (by volume) of the water in Lake Nicaragua (see Fig. 1). A considerable quantity, to be sure, but not considerable enough to forestall recognizing that water is an especially scarce commodity in near-Earth space and that its exploitation should be regulated carefully.

There are further constraints on NEA water extraction. First, not every C-type asteroid included in the above mass-estimate will be massive enough—i.e., contain enough water—to justify retrieval.[2] Thus the figure of 8×10^{11} kg should be thought of more as an *upper* bound on the water accessible from NEAs, rather than as a *lower* bound. And second, even if NEAs can be accessed at relatively low energy costs, capture and return missions must be timed *very* carefully. Missions will in general have to be planned years in advance, and in many cases they will take years to complete. The result will not be a large influx of water into cislunar space, but rather a staggered, slow trickle. For these reasons NEAs are, in general, both a less preferable and a more tenuous source of water when compared to permanently shadowed craters.

3. Fitness of existing policy

Assuming that NEWS exploitation will eventually take place, how adequately can existing regulatory frameworks accommodate the exploitation of this especially scarce resource? The author raises this question *not* as one concerning the legal status of space resource exploitation (such as under the Outer Space Treaty (OST) or under the US Space Resource Exploration and Utilization Act of 2015), which is much discussed in the literature. Rather, the author raises this as a question about what amendments or modifications, if any, would have to be made to existing treaties and regulatory frameworks in order to provide for *ethically sound* NEWS exploitation. As the author argues in this and the following section, existing policy focuses almost exclusively on the regulation of *access* to space resources (including NEWS), whereas ethical considerations compel regulating the *use* of space resources—*especially* in cases of resources that are very limited.

Existing regulatory and legal frameworks—at least those explored in the context of space resources—tend to focus principally on *access* to space rather than on *for what purposes* space resources are exploited and distributed. For instance, many of the provisions of the Outer Space Treaty (OST) are focused on access to space in the sense of outlawing activity that could interfere with the operations of other states. Thus, for understandable historical reasons, one finds in the OST a concerted effort to preserve space for “peaceful purposes.” But there is a broad array of activities that fall under the purview of “peaceful purposes”—and it is not clear that just any non-belligerent

[1] These concerns are well-explored in (Elvis, 2014).

[2] (Elvis, 2014) estimates that a C-type asteroid must be at least 18 m in diameter to justify the energy expense of capture and return, whereas the mass total identified in (Sanchez and McInnes, 2013) includes asteroids of at least 1 m in diameter.

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