EVA H$_2$O Release: Need for Measurements and Monitoring During Human Exploration of the Lunar Polar Regions

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Artemis astronauts are expected to conduct multiple EVAs (Extra-Vehicular Activity) to explore the south polar regions of the Moon. A key scientific draw to the lunar polar regions is the presence of volatiles in the lunar regolith’s shallow subsurface, and also of exposed ices in some Permanently Shadowed Regions (PSRs) (e.g., Gladstone et al. 2012, Hayne et al. 2015, Fisher et al. 2017, Li et al. 2018). While the scientific investigation of these volatile concentrations and their assessment as potential resources will obviously be a high priority for Artemis astronauts, it will be important to not contaminate the volatiles occurring naturally on the Moon by volatiles brought in and released by human EVAs, and if some contamination were to occur, to understand in detail how any such contamination could affect naturally occurring volatile concentrations.

Among the volatiles of concern, H$_2$O is the most significant in terms of the magnitude of the potential contamination. Current EVA suit systems, such as the EMU (Extravehicular Mobility Unit), and presumably the xEMU to be used on Artemis, vent H$_2$O at a rate of ~0.5 kg/hr. The release of this H$_2$O is from the following three sources, listed in decreasing order of significance: 1) the Spacesuit Water Membrane Evaporator (SWME) system, 2) the Rapid Cycle Amine (RCA) system, and 3) distributed suit leakage.

This large amount of H$_2$O venting is of significant concern for the integrity of the volatile-related science to be conducted. To put things in perspective, orbital neutron spectrometry indicates that the lunar polar regions commonly contain water equivalent hydrogen (WEH) at a concentration of a few percent within the top ~1 m of the regolith. Consistent with this estimate, the LCROSS impact experiment has yielded an H$_2$O concentration of ~5% by mass within the topmost regolith at Cabeus Crater (Colaprete et al. 2010). Considering an average regolith density of ~1.5 g/cm$^3$, the uppermost 1 cm of lunar polar regolith could thus contain, at <5% H$_2$O by mass, <0.75 kg of H$_2$O per m$^2$. Thus, each spacesuit releasing ~0.5 kg/hr is a critical factor to measure, understand, and monitor (Rosenthal et al. 2020).

We propose and recommend to NASA that Artemis astronauts include as part of their early scientific investigation of the lunar south polar region, a plan to investigate their own potential environmental impact on lunar surface and near-surface volatile concentrations, in particular their own release of H$_2$O during EVAs, including an assessment of the fate of any H$_2$O released in proximity to, and within, PSRs.
The following investigations are recommended:

Pre Artemis III Launch:

A) Measure, model, and understand in a controlled, laboratory setting, the release of H\textsubscript{2}O and other volatiles (e.g., CO\textsubscript{2}) by lunar EVA spacesuits, e.g., the xEMU.

Note that understanding H\textsubscript{2}O and other volatile release from other surface systems, such as spacecraft and landed habitats, is also important, but given that EVAs will likely bring astronauts in close proximity to PSRs, and possibly within them, H\textsubscript{2}O release from EVA suits is of the highest priority.

B) Define and adopt initial H\textsubscript{2}O and other volatile contamination mitigation strategy.

During Artemis III Mission at Lunar South Pole:

C) Monitor H\textsubscript{2}O and other volatile releases during EVAs on the Moon.

D) Carry out control experiments in small PSRs on the Moon, to investigate the fate of H\textsubscript{2}O and other volatiles (CO\textsubscript{2}).

For instance, do we observe real-time cold-trapping of EVA-vented H\textsubscript{2}O onto permanently shadowed regolith or boulder surfaces?

E) Refine and Adjust H\textsubscript{2}O and other volatile contamination mitigation strategies for future lunar polar missions.

References


