Radiation Protection on Mars.

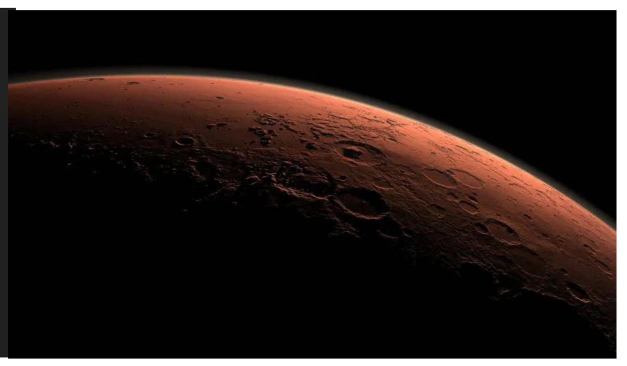


IMAGE: NASA/JPL-CALTECH

Scienteer Project # 147890

Problem / Question

What material will best protect humans from solar radiation when they live on Mars?

Hypothesis

Lead is the best shielding material for radiation protection.

Materials & Methods

Controlled variables	Independent variable	Dependent variable
• Gamma radiation	• Shielding materials	• The amount of radiation blocked by the shielding materials

Materials	Quantity
CS-137	2.0g
Lead	0.25cm thick
Martian Simulant Soil	4cm thick
Polyurethane	0.5cm thick
Polyethylene	0.5cm thick
Martian simulant soil with water. (3-1 Ratio)	4cm thick

Background Research

Earth's rich atmosphere protects humans from harmful solar radiation. Mars lacks this protection and the health of humans on that planet depend upon shielding materials that can be economically transported or found on Mars. My experiment tested how well several materials – including a simulant of Martian soil – will block radioactivity from a gamma radiation sample. The blocking power of each material was tested by a Geiger counter.

Data

Procedure

Step 1

A CS-137 isotope was measured 3X for gamma ray CPM

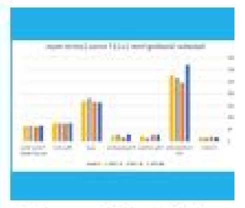
Step 2

Materials were measured using a Geiger counter.

Step 3

Record raw data from experiments.

Step 4



Compile data into analytical format.

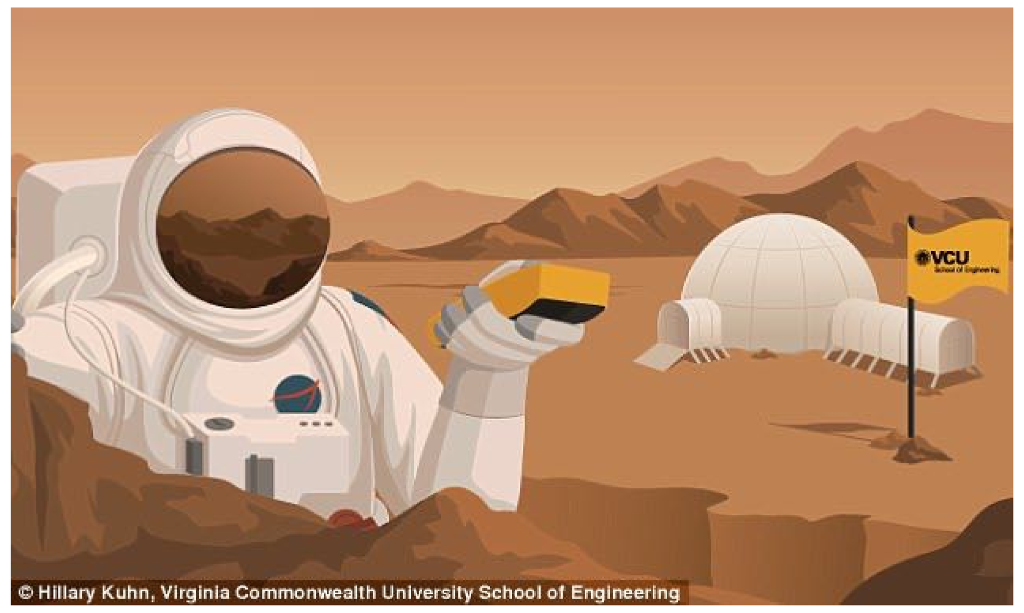
Photos

The Winner of the 2019 NASA competition for a safe Mars habitat. The habitat had to be constructed of recyclables and materials found on site.*

Observations

- Lead at 0.25 cm thickness provided the poorest shielding
- Polyurethane and polyethylene at 0.5 cm thickness provided the best shielding
- Martian simulant at 4 cm provided adequate shielding
- Martian soil frozen into 4 cm bricks with water also provided adequate shielding.

Photos

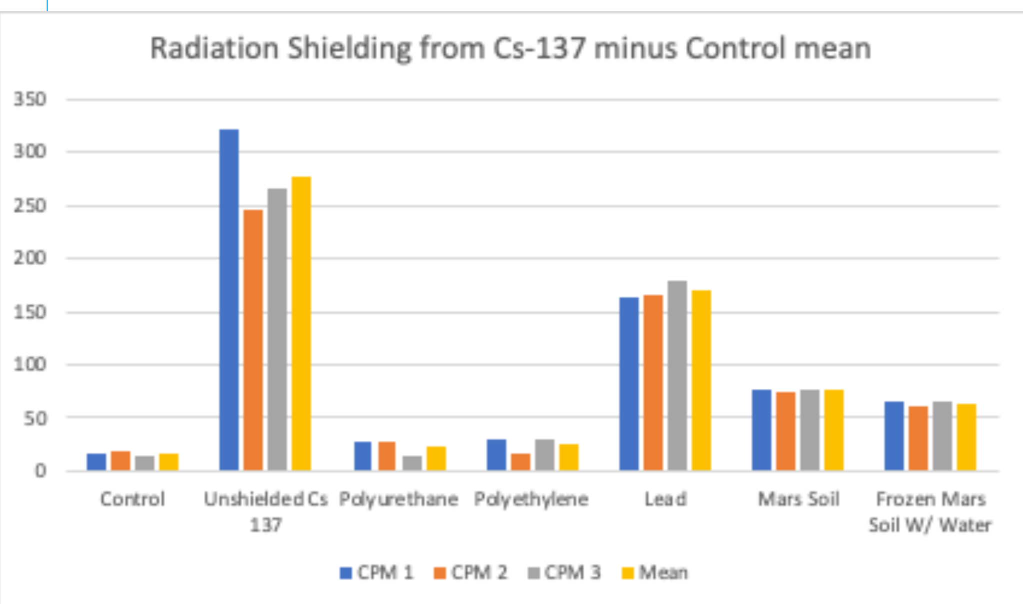


Credit: © Hillary Kuhn, Virginia Commonwealth University School of Engineering

Charts

Material	Counts Per Minute (Averaged)
Lead	186
Polyurethane	40
Polyethelene	41
Simulated Martian Soil	93
Simulated Martian Soil w/ Water	64

Graphs



Data Analysis/Statistics

- Polyurethane proved to be the best substance at blocking radiation.
- Polyethylene was recorded as the second-best shielding method.
- Frozen Mars Soil w/ water was the 3rd best method but easily the most accessible and cost effective.
- Lead did not do as expected most likely due to the thickness of the lead sheet.

Conclusion

During the course of our investigation, we concluded that the best option for blocking out radiation is frozen Martian soil with water. Both of these materials are abundant on Mars and can be used cost effectively.

Applications

- This research indicates habitats constructed of Martian soil and frozen water can protect humans on Mars.
- It also suggests that mining into the surface of Mars would provide radiation-safe habitation.

Future Research

- Further research that measures the shielding of greater thicknesses of Martian soil will be helpful in designing a safe environment.
- Polyurethane and polyethylene both provide excellent shielding. They are lighter to transport from Earth than lead. It would be useful to know how a thin skin of these materials over a soil/frozen water mixture would work.
- Binding agents other than water will be necessary for interior surfaces that are heated where frozen water cannot be used.

Photo Credit

* Grossman, David. "NASA Crowns Winner in Mars Habitat Competiton," "Popular Mechanics," 19 May 2019, https://www.popularmechanics.com/technology/infrastructure/a27432340/nasa-crowns-mars-habitat-competition-winner/

Credit: © Hillary Kuhn, Virginia Commonwealth University School of Engineering
IMAGE: NASA/JPL-CALTECH

The alternatives to lead shielding provide a 2x to 4x+ greater protection against radiation.
However, at the thicknesses tested, they would still allow a dangerous environment.
The “Suggestions for Further Research” include recommendations to test thicker versions of these materials.

Material	Counts per Minute (Ave.)	mSv/h*
Lead	186	1.06
Polyurethane	40	0.228
Polyethelen	41	0.233
Simulated Martian Soil	93	0.53
Sinulated Martian Soil with Water, frozen	64	0.365
*cpm converted x .0057		

So, here’s a simple, plain-English chart of radiation doses in **millisieverts (mSv/h)**and **microsieverts (μSv/h)** per hour. Most dosimeters (the handheld Geiger counters that measure your body’s “Dose”) operate in these units.

mSv/h	**μSv/h**	**Health Risk**	
10,000	10,000,000	Organ failure and death within hours	
1,000	1,000,000	Severe: Vomiting / 1:20 risk of cancer	
100	100,000	Severe: Radiation poising	
1	1,000	High danger: Evacuate immediately	Lead
0.1	100	High danger: Heightened sickness risk	Polyurethane, Polyethylene, Simulated Martian soil, Simulated Martian Soil w/ water
0.02	20	High danger: Sickness risk	
0.01	10	Danger: Relocate now	
0.005	5	Elevated risk: Relocate as soon as possible	
0.002	2	Elevated risk: Take safety precautions	
0.001	1	Safe: Short-term habitation only	
0.0005	0.5	Safe: Medium to long term habitation	
0.00020	0.20	Safe: Long-term habitation (normal levels)	

https://darwinsdisciple.com/2018/02/25/really-simple-guide-to-radiation-levels-in-µsv-h-and-msv-h/

Project Forms

Abstract

•Introduction

The purpose of this experiment is to find a method of blocking deadly solar radiation on Mars. This will be important to achieving humanity's goal of establishing a colony on the red planet. By safely living on Mars, Earth will expand its ability to explore the solar system.

•Problem Statement

During the course of this experiment, we determined the best, and most accessible material that could be used to block radioactive waves. Our hypothesis was that lead would be the safest option on the red planet, but our investigations found otherwise.

•Procedures

We tested our hypothesis by measuring different materials. We used a Geiger counter and the radioactive substance Cs-137. Each material was placed between Cs-137 and the Geiger counter, then the number Counters Per Minute (CPM) was recorded. Each material was measured 3 times.

•Results

The unshielded Cs-137, our control variable, had 294 CPM average. Contrary to our prediction, lead was not the best shielding with an average of 186 CPM. Polyurethane had an average of 40 CPM and polyethylene had a CPM of 41. To create bricks of Martian soil, we tested was a combination Martian soil mixed 3:1 with water and frozen. The average of this combination was 64 CPM.

•Conclusions

Even though the plastic resins had better CPM, I believe that the Martian soil, or Martian soil mixed with water and frozen, will be the best choice simply because of its availability without transportation costs. Burrowing into Martian soil might be the best solution.