Environmental Geochemistry Laboratory
Experiments with Ultraviolet Radiation and the Greenhouse Effect

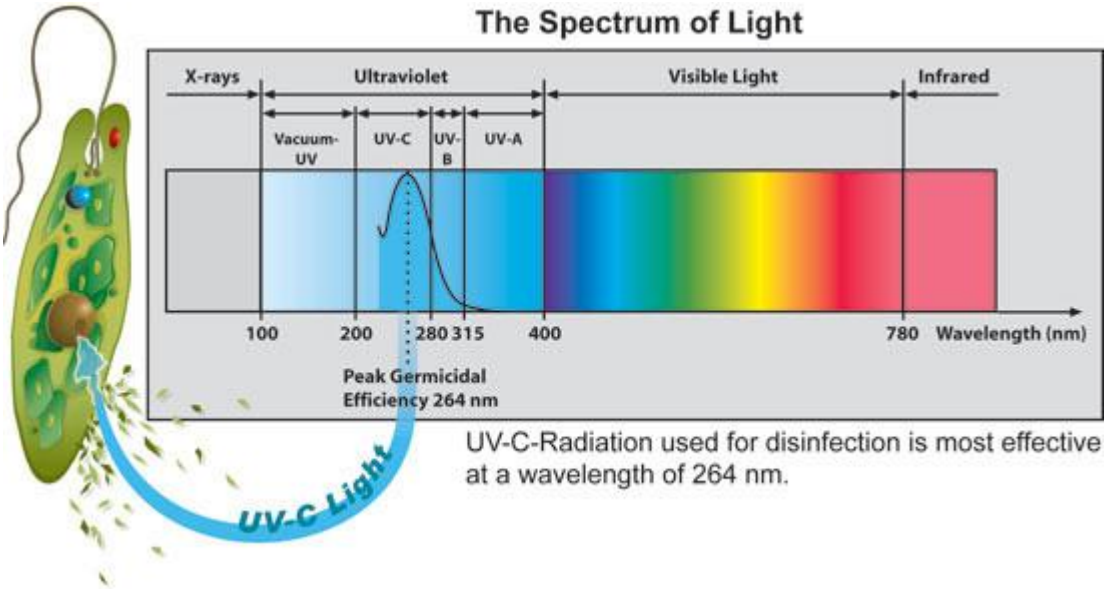

Image from uvcomparison.com

Terminology

1. *Ambient temperature*: local air temperature
    a. Measure approximately 6 feet (2 m) off the ground in the shade and away from large structure such as buildings
    b. Record in either C or F.
2. *Insolation*: the amount of solar radiation reaching the ground
    a. Reported it as Watts per meter squared (W/m^2)
    b. Varies with season, latitude, and weather conditions.
3. *Pyranometer*: an instrument used to measure the amount of solar radiation (power) the sun produces in a specific location.
    a. Typically used in conjunction with a multimeter for a reading to be obtained
    b. Measure with the pyranometer and meter set for V(DC) in millivolts (mV)
    c. Record it as the mV. Convert it to W/m^2 later (multiply by 5).

Background

The solar constant is the average solar radiation reaching the top of the earth's atmosphere over one year. This value is approximately 1366 W/m^2. The radiation is distributed throughout the electromagnetic spectrum. At the earth's surface, the insolation is approximately 1000 W/m^2 for a surface perpendicular to the sun's rays at sea level on a clear day. The average insolation for the Earth on a clear day is approximately 250 W/m^2, taking into account the lower intensity in morning and evening and its near-absence at night.

Ultraviolet light is divided into four distinct spectral areas: (1) Vacuum UV (100 to 200 nanometers); (2) UV-C (200 to 280 nm); (3) UV-B (280 to 315 nm); and (4) UV-A (315 to 400

nm). The Sun emits ultraviolet radiation in the UVA, UVB, and UVC bands, but because of absorption in the atmosphere's ozone layer, 98.7% of the uv radiation that reaches the Earth's surface is UVA. Some of the UVB and UVC radiation is responsible for the generation of the ozone layer. The UV-C spectrum is the most lethal range of wavelengths for microorganisms, but most is filtered out by the atmosphere.

UVB light can cause direct DNA damage and sunburn. Both UVA and UVB destroy vitamin A in skin which may cause further damage. In the past, UVA was considered less harmful, but today it is known that it can contribute to skin cancer via indirect DNA damage (free radicals and reactive oxygen species). It penetrates deeply but it does not cause sunburn. Sunscreen prevents the direct DNA damage which causes sunburn. Most of these products contain an SPF rating to show how well they block UVB rays but not UVA rays. The U.S. Food and Drug Administration is considering adding a system to rate UVA protection as well. Lotions with compounds such as zinc oxide or titanium dioxide help protect against UVA and UVB radiation.

Procedure

Part 1. Greenhouse Effect

Compare the temperature of water

1. In the shade
2. In the sun
3. In a "greenhouse"

Be sure to also record the air temperature in the sun and in the shade.

Measure the energy recorded by the pyranometer in millivolts (mv). Convert that to W/m^2 by multiplying by 5. Report the insolation

1. In the shade
2. In the sun
3. Under cloudy conditions (if possible)

Part 2. Ultraviolet Radiation

Conduct at least three experiments which demonstrate differences in uv radiation absorption. Be sure to always use a control. Use a color intensity scale of 0 (no change) to 5 (deepest color change) for recording differences. It may also help to record the time it takes for the color to change, which will vary with cloud cover.

1. One experiment should test the effectiveness of various levels of sunscreen. To do this, place UV-detecting beads in a labeled plastic bag, coat the bag with the indicated level of sunscreen, and then expose all bags to uv light at the same time.
2. A second experiment should compare different colored plastic or glass bottles.
3. Your group should come up with a third experiment.

Be sure to completely write down the procedure for each of the three experiments (as if someone else would follow the instructions to conduct the same experiment) and record all observations in a logical, scientific way. Determine the best way to present the results and conclusions and include these items in your lab report.

Post Lab Questions

1. Explain how this solar cooker acts as a model for global warming.

2. Did any of your observations surprise you? If so, which and why? If not, explain the reasoning behind your correct predictions.

3. What personal conclusions did you reach from these uv and greenhouse experiments?