Solar greenhouses are the enclosures where crops, vegetables, flowers and plants can be grown under unfriendly climatic conditions. You know that the plant growth gets affected by availability of light, moisture, ambient temperature and carbon dioxide. It is possible to design enclosures which admits sunlight when it is desired and at the same time controls inside temperature within acceptable range. Usually, solar greenhouse find application in cold areas where vegetation is damaged due to extreme low temperatures. You will be happy to see that the greenhouse effect is a natural process.

You have already studied the solar radiation and its characteristics in OYE-002, Block 1, Unit 1. The amount of solar radiation incident on the earth’s surface is almost constant and has the value of 1347 W/m² and is called the solar constant. A faction of the solar radiation is reflected back to the atmosphere by the clouds and the earth’s surface. The radiation reflected by the clouds is called the albedo and has the value of about 30%. A fraction of the radiation is absorbed by the earth’s surface until it emits the same amount of radiation. The radiation emitted by the earth’s surface at room temperature is in infrared range.

After studying this unit, you will be able to:

- understand greenhouse effect,
- different types of greenhouses,
- design principles of greenhouses, and
- different uses of greenhouses.
4.2 GREENHOUSE EFFECT

It is only because of greenhouse effect that our life on Earth is possible to a great extent. Imagine for a moment that natural greenhouse in not there. What will be its effect? Without natural greenhouse the Earth's surface temperature would be 33°C cooler – a chilly – 18°C rather than the tolerable 15°C. The natural greenhouse is due to naturally occurring greenhouse gases such as water vapour, carbon dioxide, methane and nitrous oxide. If this is so then you may be wondering why we are so afraid with greenhouse effect. The reason of our worry is that due to rapid industrialization and extensive use of fossil fuels, the concentrations of greenhouse gases are increasing at an alarming rate.

The greenhouse effect is referred to the rise in temperature due to absorption of infrared radiation. You may better understand the greenhouse effect by seeing the Figure 4.1. You can see that earth absorbs the solar radiation. The earth emits long wavelength infrared radiations. These radiations are absorbed by the greenhouse gases and hence can’t escape. The net effect is the result of increase of mean annual temperature.

Let us further understand this by examining the greenhouse effect as depicted in Figure 4.2. The following things are happening:

1. The solar radiation is incident on the upper atmosphere.
2. A fraction of it is absorbed by the earth.
3. A fraction of the radiation absorbed by the earth is radiated towards the atmosphere.
4. A fraction of the radiation absorbed by the atmosphere is reflected back to outer space.
5. The atmosphere emits radiation towards upper atmosphere and towards earth.
If the atmosphere absorbed all the infrared radiation emitted by the earth and continue to transmit all the incident radiation, the atmosphere will get heat up. The atmosphere radiates into outer space and towards the earth’s surface in equal amounts. The earth’s surface receives more radiation and gets heat up. This is greenhouse effect.

![diagram of greenhouse effect]

**Figure 4.2 : Overview of Greenhouse Effect**

### 4.3 IMPACT OF GREENHOUSE EFFECT IN NATURE

Before discussing details of solar greenhouses, it would be interesting for you to learn how the greenhouse effect in nature is affecting us, and how we can contribute in decelerating its growth.

The impact of greenhouse effect is the Global warming which in turn is affecting entire ecosystem and health of the people. The significant temperature rise is going to have drastic social, economic and ecological implications. The global warming is affecting the human society in many ways like causing the storms, hurricanes, floods and droughts, glaciers and polar ice is melting, sea levels is rising, forest fires cases are increasing and tropical diseases are increasing.

#### 4.3.1 Greenhouse Gases

The naturally occurring greenhouse gases are water vapour, carbon dioxide, methane and nitrous oxide. The man made greenhouse gases are also the same. What actions generate these greenhouse gases is given in Table 4.1.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Carbon dioxide, CO₂</td>
<td>Burning of fossil fuels</td>
</tr>
<tr>
<td>2</td>
<td>Methane, CH₄</td>
<td>Anaerobic bacteria in rice fields, sewage</td>
</tr>
<tr>
<td>3</td>
<td>Nitrous Oxide, N₂O</td>
<td>Fossil fuels and fertiliser</td>
</tr>
<tr>
<td>4</td>
<td>Chlorofluorocarbon, CFCs</td>
<td>Refrigeration</td>
</tr>
</tbody>
</table>
4.3.2 Climate Change

You will be surprised to know that various climatic models developed to predict the atmospheric temperature indicate that the atmospheric temperature is going to increase by between 1.5 and 4.5°C by the year 2100 if significant efforts are not made to control the emissions of greenhouse gases. An increase of about 5°C in the global temperature since the last ice age (10,000 years ago) has already happened. It is estimated that the Earth's average temperature has risen by 0.5 to 0.6°C since 1880 because of emissions of greenhouse gases from burning of fossil fuels and other human activities.

You can see the effect of rising temperature by observing Figure 4.2. You can see that rising temperature leads to multiple effects like changes in regional wind systems, global rainfall, coral bleaching, destruction of coral reefs, growth in insect populations, negative effect on agriculture and human health, etc.

At this point, you may be in a position to differentiate between the greenhouse effect, global warming and climate change. All these three terms are interlinked. You may understand these terms in better ways by considering a problem and then its consequence or cause and its effect as shown in Figure 4.3. You can see that the greenhouse effect is the cause and global warming and climate change are the consequences. The increase in the temperature of the Earth's lower atmosphere is the global warming. The alterations such as rainfall patterns, evaporation and cloud formation result in climate changes.

4.3.3 Steps for Reducing Greenhouse Effect in Nature

Now you may be thinking what an individual can do about greenhouse effect. Each one of us can help to reduce the impact of greenhouse. Some of the simple steps are listed below:

A: Greenhouse Education

- You should make serious efforts to know all about the greenhouse effect, global warming and climate change.
- You must understand that consumption of the fossil fuels in making our energy requirements produces greenhouse gases which are responsible for greenhouse effect.
- Consuming more energy therefore leads to more greenhouse effect.
- You should make serious efforts to know about alternate energy sources.
B : Energy Conservation

- Energy conservation is in your hands. You should always remember that energy saved is more than the energy produced.
- The main greenhouse gas, CO$_2$, comes from the burning of fossil fuels. You can help in reducing the emissions of CO$_2$ by reducing consumption of electricity and energy in transportation.
- A car produces CO$_2$ roughly 2 tonnes per year.

You will learn more about energy conservation in OET-003. We will give some tips which you can follow immediately for saving electricity.

C : Save Electricity

- Switch off the lights and any other electrical appliances (like ACs, TVs, radio) when not in use.
- Start making use of energy efficient lamps.
- Always use energy efficient appliances. They may cost more initially but will be more advantageous in long run.

D : Save Petroleum Fuels

- Easiest and more effective way is to reduce private transport. You may adopt a car pool to go to work or elsewhere.
- Make sure that your own vehicle is fuel efficient.
SAQ 1
Give five steps which you can follow in order to reduce the effect of greenhouse.

SAQ 2
What are the effects of global warming?

Figure 4.3: Difference between Greenhouse Effect, Global Warming and Climate Change

4.4 SOLAR GREENHOUSE

The most important purpose of a greenhouse is to collect solar energy to raise the indoor temperature and also store heat for use during night. Solar greenhouses are climate controlled.

The crops may be grown in solar greenhouses under favorable controlled environment, viz. temperature, humidity, light intensity, ventilation, soil media, disease control, irrigation and other agronomical practices throughout the season irrespective of the natural conditions outside.
The greenhouse technology available today is suitable for:

- Production of vegetable crops.
- Production of off-season flowers, vegetables.
- Production of roses, carnation, cut-flowers, etc.
- Plant propagation, raising of seedlings.
- Primary and secondary hardening nursery of Tissue cultured plant.

The basic principle of solar greenhouses is that the solar radiation coming from the sun passes through the glass cover, but the radiation emitted by the heated surfaces present inside the enclosure cannot escape as the glass is opaque for longer wavelength radiation.

**SAQ 3**

Explain the difference between greenhouse effect, climate change and global warming.

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An interesting thing about solar greenhouses is that there are choices to choose from and to suit the needs for various applications. Solar greenhouses could be of stand alone structure type to cater to larger capacity requirements. Solar greenhouses are also constructed to meet limited domestic requirements of growing vegetables as an attachment to the existing building. Depending upon the use of auxiliary energy source, the solar greenhouses are broadly classified as passive and active greenhouse. These two makes use of different resources, but still serve a same purpose.

### 4.4.1 Passive Solar Greenhouse

The passive solar greenhouse does not make use of mechanical devices like motors, fans, etc. for transferring the solar heated air from the storage area to the other parts of the greenhouse.

### 4.4.2 Active Solar Greenhouse

The active solar greenhouse makes use of mechanical devices like motors, fans etc for transferring the solar heated air from the storage area to the other parts of the greenhouse.

### 4.4.3 Solar Heat Storage

The main feature in designing a solar greenhouse is that there must be sufficient amount of solar heat stored for use when sun is not shining. The solar energy can be stored by making use of rocks or concrete, etc. in the floor and the walls of the greenhouse.
4.5 DESIGNING OF SOLAR GREENHOUSE

Solar greenhouses have the following features:

- Solar greenhouse should be elongated along east-west axis to have longer south side to allow receipt of maximum solar radiation.
- North wall could be made opaque, especially in regions where sub-zero ambient temperatures are experienced.
- To prevent one sided growth of the plants, ceiling and upper part of the north wall should be made white painted to reflect sunlight onto the plants.
- Double glass cover can also be used in regions with severe winters for constructing solar greenhouse.
- Provision of openings to be provided to evacuate extra heat through ventilation during periods of temperatures higher than acceptable.
- Solar greenhouse makes use of heat storing materials to retain solar heat. Pebbles can be provided in the floor with top surface painted in dark colour to capture maximum solar heat. This heat can be blown in during night to keep inside warm.
- Plastic sheets can also be used in place of glass for constructing solar greenhouse, however, these needs to be UV_stabilized to have their longer life.

4.6 LET US SUM UP

While discussing about solar greenhouses, in this unit you have learned all about greenhouse effect, global warming and climate change. You have also learned how to reduce their impact.

The greenhouse effect is referred to the rise in temperature due to absorption of infrared radiation. The Earth absorbs the incoming solar radiation. The earth emits long wavelength infrared radiations. These radiations are absorbed by the greenhouse gases and hence can’t escape. The net effect is the result of increase of mean annual temperature.

The impact of greenhouse effect is the Global warming which is turn is affecting entire ecosystem and health of the people. The global warming is affecting the human society in many ways like causing the storms, hurricanes, floods and droughts, glaciers and polar ice is melting, sea levels is rising, forest fires cases are increasing and tropical diseases are increasing.

The naturally occurring greenhouse gases are such as water vapour, carbon dioxide, methane and nitrous oxide. The man made greenhouse gases are more or less similar. The main source of the greenhouse gases is the burning of fossil fuels for various applications. It is estimated that we are adding about 2 billion tons of carbon in the overall carbon cycle.

The rising temperature leads to multiple effects like changes in regional wind systems, global rainfall, coral bleaching, destruction of coral reefs, growth in insect populations, negative effect on agriculture and human health, etc.
The greenhouse effect, global warming and climate change are interlinked. The greenhouse effect is the cause and global warming and climate change are the consequences. The increase in the temperature of the Earth's lower atmosphere is the global warming. The alterations such as rainfall patterns, evaporation and cloud formation result in climate changes.

The solar greenhouse technology available today is suitable for production of vegetable crops; production of off-season flowers, vegetables; production of Roses, Carnation, cut-flowers, etc. plant propagation, raising of seedlings; primary and secondary hardening nursery of tissue cultured plant. This technology has high potential in areas with severe winter conditions.

### 4.7 KEY WORDS

**Carbon Dioxide (CO\(_2\))**
A product of combustion.

**Carbon Monoxide (CO)**
A colorless, odorless, highly poisonous gas made up of carbon and oxygen molecules formed by the incomplete combustion of carbon.

**Chlorofluorocarbons (CFSs)**
A family of artificially produced chemicals; used as refrigerants, solvents and in the production of foam material; composed primarily of carbon, hydrogen, chlorine, and fluorine.

**Greenhouse Gases**
The greenhouse gases are carbon dioxide (CO\(_2\)), methane (CH\(_4\)), nitrous oxide (N\(_2\)O), ozone (O\(_3\)), and water vapor (H\(_2\)O). They allow visible light and ultraviolet light (short-wave radiation) to pass through the atmosphere and heat the earth's surface. This heat is re-radiated from the earth in form of infrared energy (long-wave radiation). The greenhouse gases absorb part of that energy before it escapes into space.

**Greenhouse Effect**
A warming of the Earth and its atmosphere caused by greenhouse gases and water vapor trapping heat from the sun.

### 4.8 ANSWERS TO SAQS

**SAQ 1**
The five steps for reducing the impact of greenhouse effect are:

1. **Greenhouse Education**: Know all about the greenhouse effect, global warming and climate change and make others also to know about them.
2. **Know About Alternate Energy Sources**: You should make efforts to know renewable energy sources and how to use them.
3. **Adopt Energy Conservation**: It is in your hands. Always remember that energy saved is energy produced.
(4) Save Electricity: Switch off some thing some where which is not in use, starting using energy efficient appliances.

(5) Save Petroleum Fuels: Make sure that your own vehicle is fuel efficient.

SAQ 2
Global warming is the consequence of the greenhouse effect and is causing harm to the environment and health of the people. The significance effects of global warming are (1) harm to the entire ecosystems, (2) the storms, hurricanes, floods and droughts are increasing, (3) glaciers and polar ice is melting, (4) sea levels is rising, (5) forest fires cases are increasing and (6) tropical diseases are increasing.

SAQ 3
The greenhouse effect, global warming and climate change are interlinked. The greenhouse effect is the cause and global warming and climate change are its consequences. The increase in the temperature of the Earth's lower atmosphere is the global warming. The alterations such as rainfall patterns, evaporation and cloud formation result in climate changes.
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