



# Fundamentals of processing plant design

# INTRODUCTION

- ❖ **Plant design refers to the overall design of a manufacturing enterprise /facility. It moves through several stages before it is completed.**
- ❖ **The stages involved are : identification and selection of the product to be manufactured, feasibility analysis and appraisal, design, economic evaluation, design report preparation, procurement of materials including plant and machinery construction, installation and commissioning.**
- ❖ **The design should consider the technical and economic factors, various unit operations involved, existing and potential market conditions etc.**

# Plant design specifies:

- **The equipment to be used performance requirements for the equipment interconnections and raw material flows in terms of flow charts.**
- **Plant layouts the placement of equipment, storage spaces, shop facilities, office spaces, delivery and shipping facilities, access ways, site plans.**
- **Elevation drawings required instrumentation and controls, and process monitoring and control interconnections utility and waste treatment requirements, connections.**
- **Facilities the rationale for site selection the basis for selecting and sizing critical pieces of equipment ways in which the design was optimized and the engineering basis for such optimization.**

# Plant design situations may arise due to one or more of the following:

- Design and erection of a completely new plant.
- Design and erection of an addition to the existing plant.
- The facility or plant operations and subsequent expansion restricted by a poor site, thereby necessitating the setting up of the plant at a new site
- Addition of some new product to the existing range.
- Adoption of some new process /replacement of some existing equipment
- Modernization / automation of the existing facility.
- Expansion of the plant capacity.
- Relocating the existing plant at a new site because of new economic, social, legal or political factors.

# **FACTORS INFLUENCING PLANT LOCATION**

**Fundamental (Primary)  
Factors**

**Derived (Secondary)  
Factors**

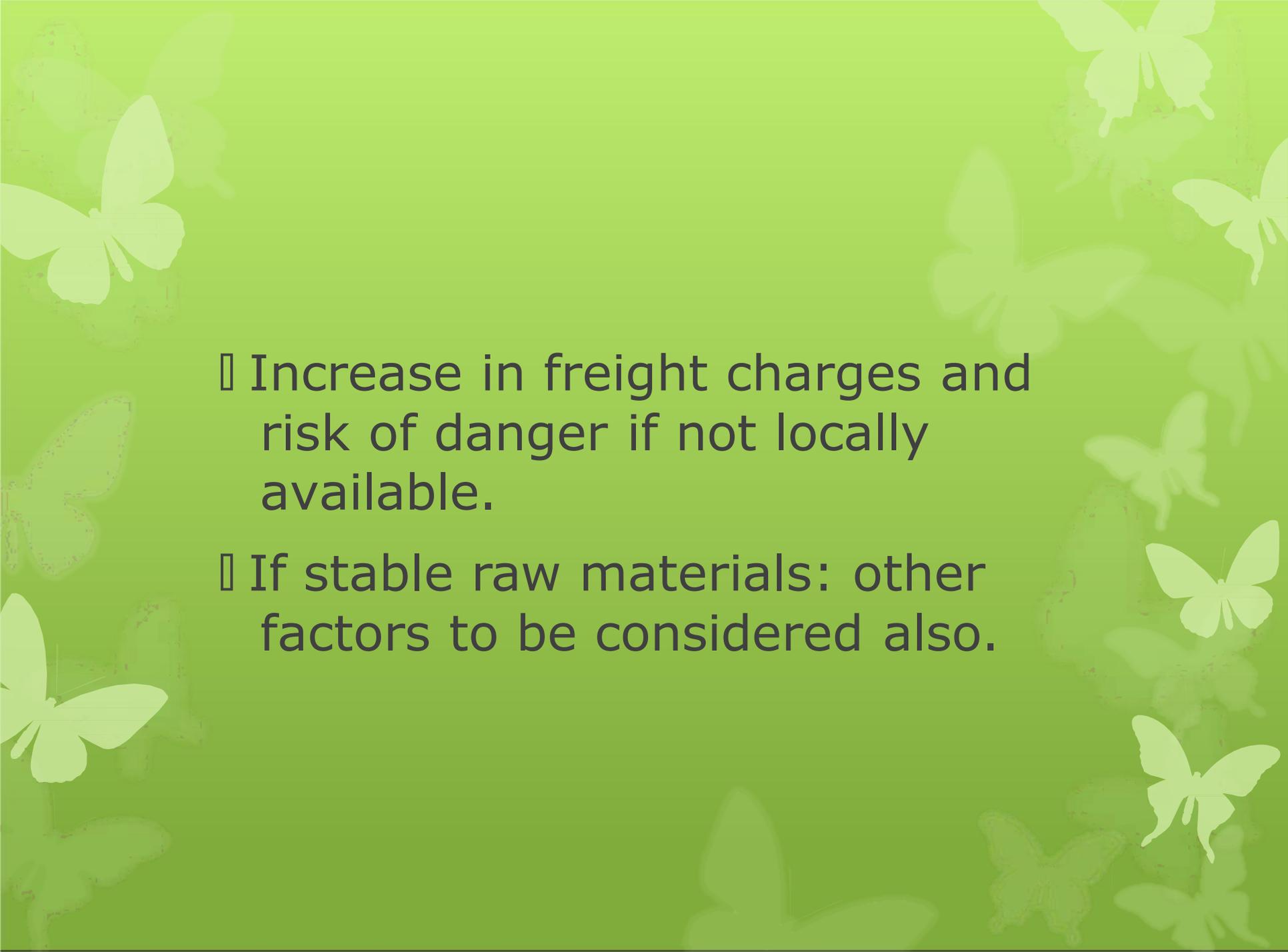
# FUNDAMENTAL/ PRIMARY FACTORS

## 1. Raw materials:

▣ Types of raw materials used:

- a) Crude drugs
- b) Inorganic chemicals
- c) Organic chemicals

▣ Economical to locate the plant near the source.

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- The background is a solid light green color. It is decorated with numerous white butterfly silhouettes of various sizes and orientations, scattered across the entire surface. The butterflies are simple line-art style drawings.
- ▣ Increase in freight charges and risk of danger if not locally available.
  - ▣ If stable raw materials: other factors to be considered also.

## **2. Market:**

- ▣ Strong influence on the establishment of industries.
- ▣ The bulk industries are located nearer to the market.
- ▣ Bulk drug industry located where drug formulation industries are located, since bulk drugs are the feed for the formulations and buyers are found nearby.

### **3. Energy availability:**

- ▣ Fuel and power
- ▣ Can also create own power generation facility.

### **4. Transportation Facility:**

- ▣ For bringing raw materials and distribution of finished goods.
- ▣ Railways, roads and seaport.
- ▣ The kind and amount of products and raw materials determine the most suitable type of transportation facility.
- ▣ Also a need for transportation for the personnel.

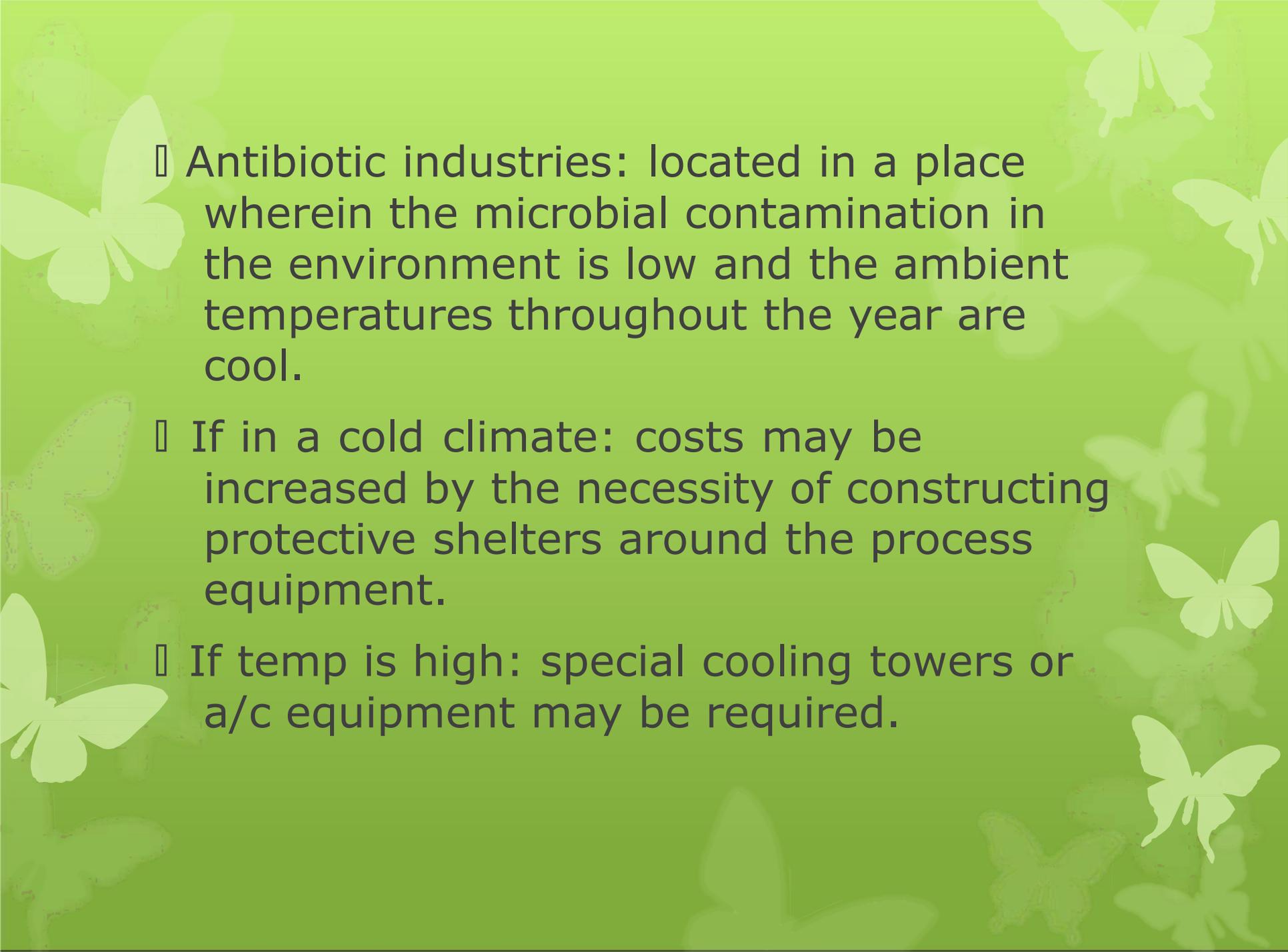
## **5.Labour Supply:**

- ▣ Low wages and abundant labour help in localization.
- ▣ Skilled, better paid and highly mobile labour required.

# DERIVED/ SECONDARY FACTORS

## 1. Climate and Soil:

- ▣ Important for agriculture based industries. E.g.:  
Ayurvedic drugs
- ▣ A location which is very hot during summers would not be suitable as it is subjected to dust storms and drying up of water supplies.
- ▣ Highly humid area will also not be suitable from the point of:
  - ▣ Cost,
  - ▣ Contamination,
  - ▣ Difficulties of maintaining laboratory animals in proper condition
  - ▣ Efficiency of labour

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- ▣ Antibiotic industries: located in a place wherein the microbial contamination in the environment is low and the ambient temperatures throughout the year are cool.
  - ▣ If in a cold climate: costs may be increased by the necessity of constructing protective shelters around the process equipment.
  - ▣ If temp is high: special cooling towers or a/c equipment may be required.

## **2. Government concessions:**

- Govt. subsidies and concessions have been provided for the industries located in certain notified areas.
- These areas have been declared as industrially backward and the govt. offers low wages, cheap power, tax concessions, etc.

### **3. Water supply**

- ▣ Large quantities of water required for cooling, washing, steam generation and also as raw material (liquid orals).
- ▣ Study should be conducted regarding the supply position of underground water and/or surface water and their seasonal variation.
- ▣ Quality of water also important.
- ▣ Temperature, mineral content, silt or sand content, bacteriological content, cost of supply and purification treatment must also be considered while choosing a water supply.
- ▣ Detailed estimate of water requirements for the present and the future must be made.

## **4. Water Disposal:**

- ▣ Legal restrictions must be considered.
- ▣ Site selected should have adequate capacity and facilities for correct waste disposal.
- ▣ Attention should be given to potential requirements for additional waste treatment facilities.

## **5.Site Characteristics:**

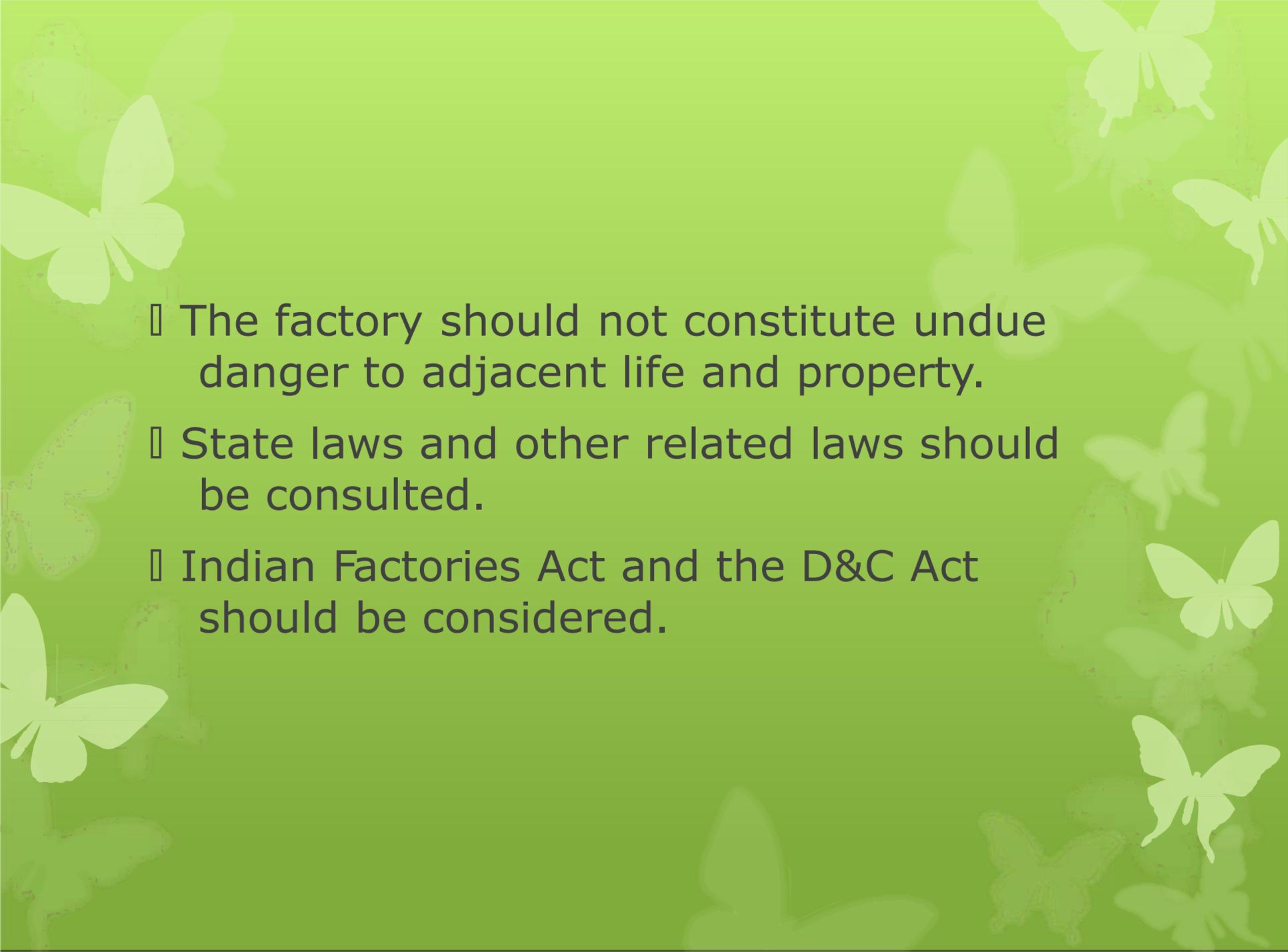
- ▣ Topography of the land and soil should be considered since both may influence the construction cost.
- ▣ Cost of land, local building costs and living conditions are also important.
- ▣ Expansion of the plant in future should also be considered.

## **6. Flood and Fire protection:**

- ▣ A regional history of natural events like floods and hurricanes must be conducted if located near large bodies of water (river, sea, etc.).
- ▣ Assistance from fire deptt. should be easily available.
- ▣ Fire hazards in the immediate surrounding area of the plant site must not be overlooked.

# Special provisions of Factory Premises- Location

- ▣ Should be located in a sanitary place away from filthy surroundings.
- ▣ Should be situated in a place which:
  - a. Shall not be adjacent to an open sewage, drainage or public lavatories.
  - b. Shall not be adjacent to a factory, which produces disagreeable or obnoxious odours or fumes.
  - c. Shall not be adjacent to a factory, which emits large quantities of soot, dust or smoke.

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- ▣ The factory should not constitute undue danger to adjacent life and property.
  - ▣ State laws and other related laws should be consulted.
  - ▣ Indian Factories Act and the D&C Act should be considered.

# PLANT LAYOUT

- ▮ *Plant layout* is a coordinated effort to achieve the final objective to integrate machines, materials, and personnel for economic production.
- ▮ *Layout* can be described as location of different deptts and arrangement of machinery in a deptt.
- ▮ Proper layout has the advantage from the point of workers, labour costs, other production costs, supervision and capital investment.

# **TYPES OF LAYOUTS**

**Process or Functional  
Layout**

**Product or Straight Line  
Layout**

# Process or functional Layout

- In this type, all machines of a particular class doing a particular type of work are arranged together in a separate deptt.
- Advantages of this type are:
  - a. More effective supervision can be achieved.
  - b. Division of labour or specialized work can be provided.
  - c. Less disruption of production is possible.
  - d. Good scope for expansion.

# Product or Straight Line Layout

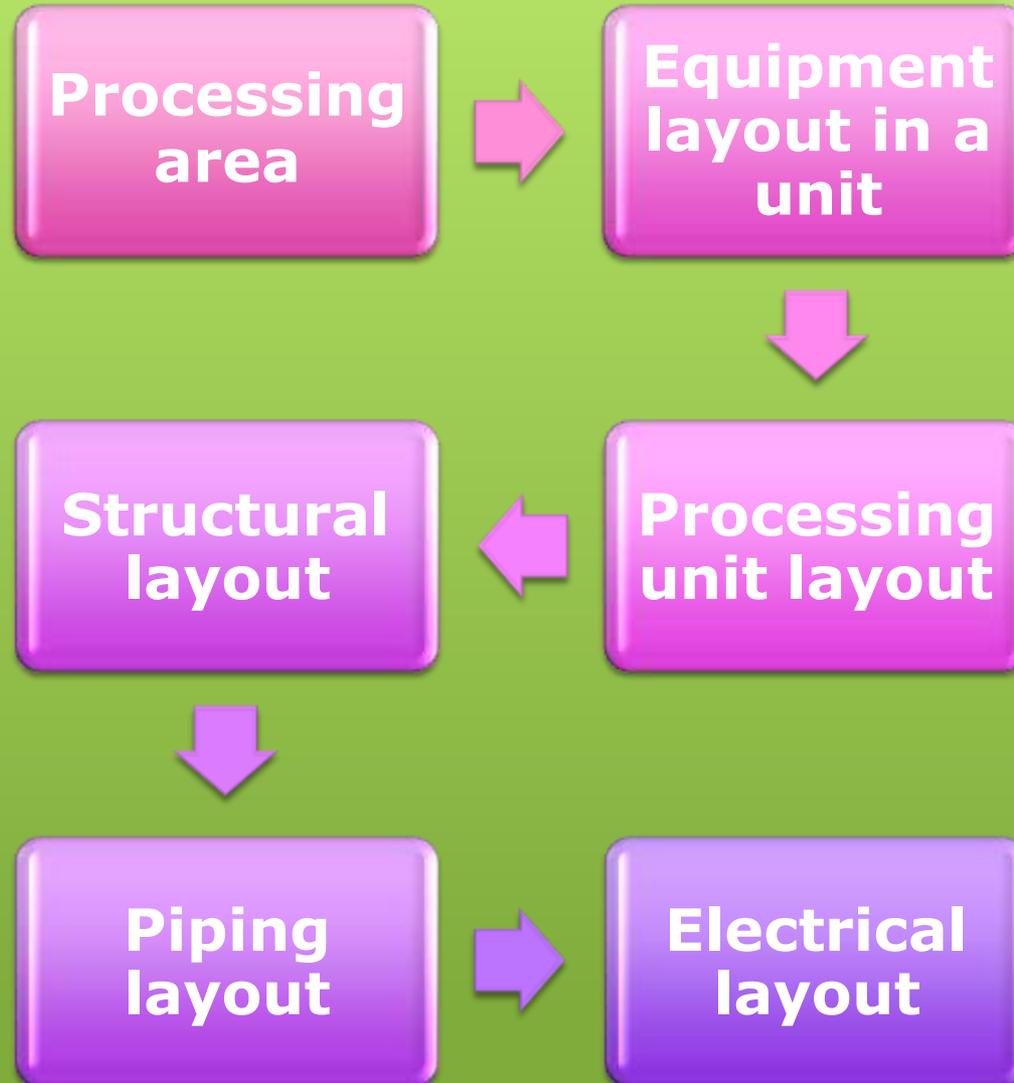
- ▣ All machines doing various operations are arranged in a line.
- ▣ Advantages:
  - a. Facilitates quick and smooth processing of work.
  - b. Reduces cost of material handling using conveyor.
  - c. Reduces manufacturing time and speeds up the manufacturing cycle.
  - d. Facilitates proper use of the floor.
  - e. Reduces inventory in work of progress.
  - f. Reduces inventory of finished goods.

# **Procedures of Layout**

**Identification**

**Drawing of plant layout**

# Identification



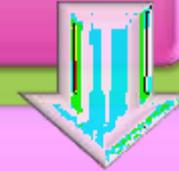
# Identification

**Handling area**

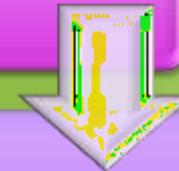
**Storage area**

# Drawings of Plant Layout

Scale drawing with elevation for equipment and process



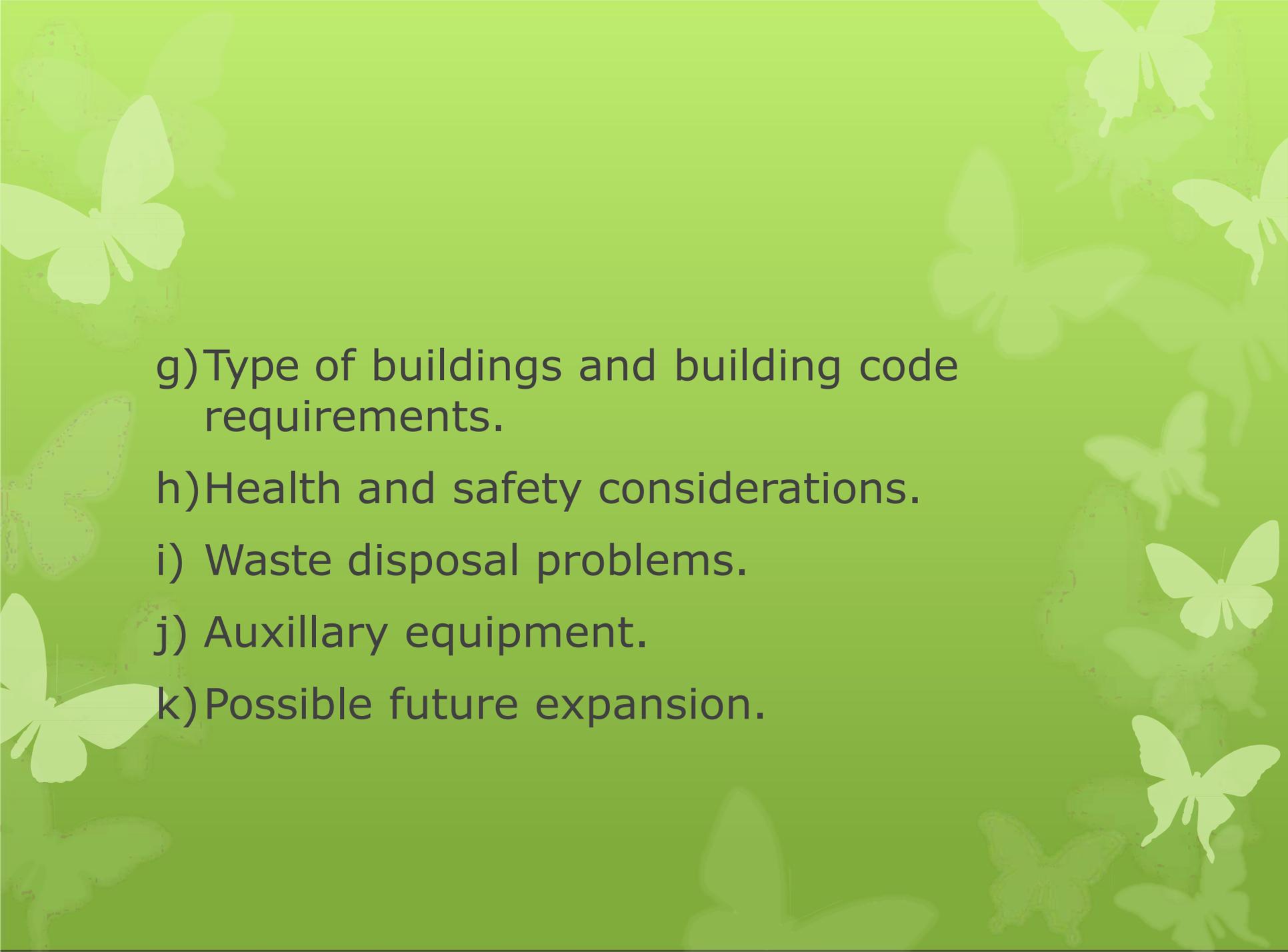
Analysis of layout: 3D model, computer graphics



Detailed drawing

# Factors guiding the layout:-

- a) New site development or additions to a developed site.
- b) Type and quantity of products to be produced.
- c) Types of process and product control.
- d) Space available and space required.
- e) Operational convenience and accessibility.
- f) Economic distribution of utilities and services.



g) Type of buildings and building code requirements.

h) Health and safety considerations.

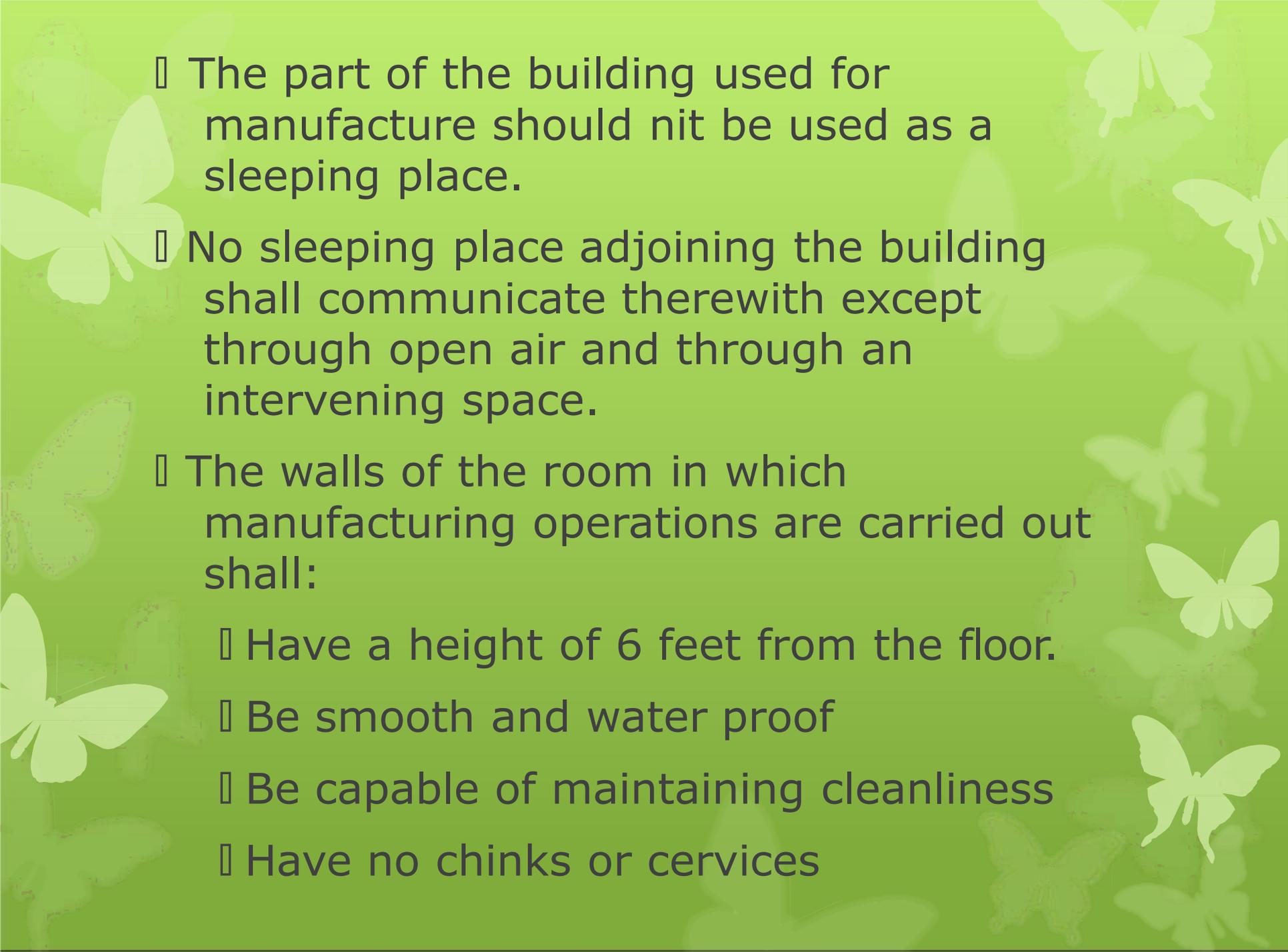
i) Waste disposal problems.

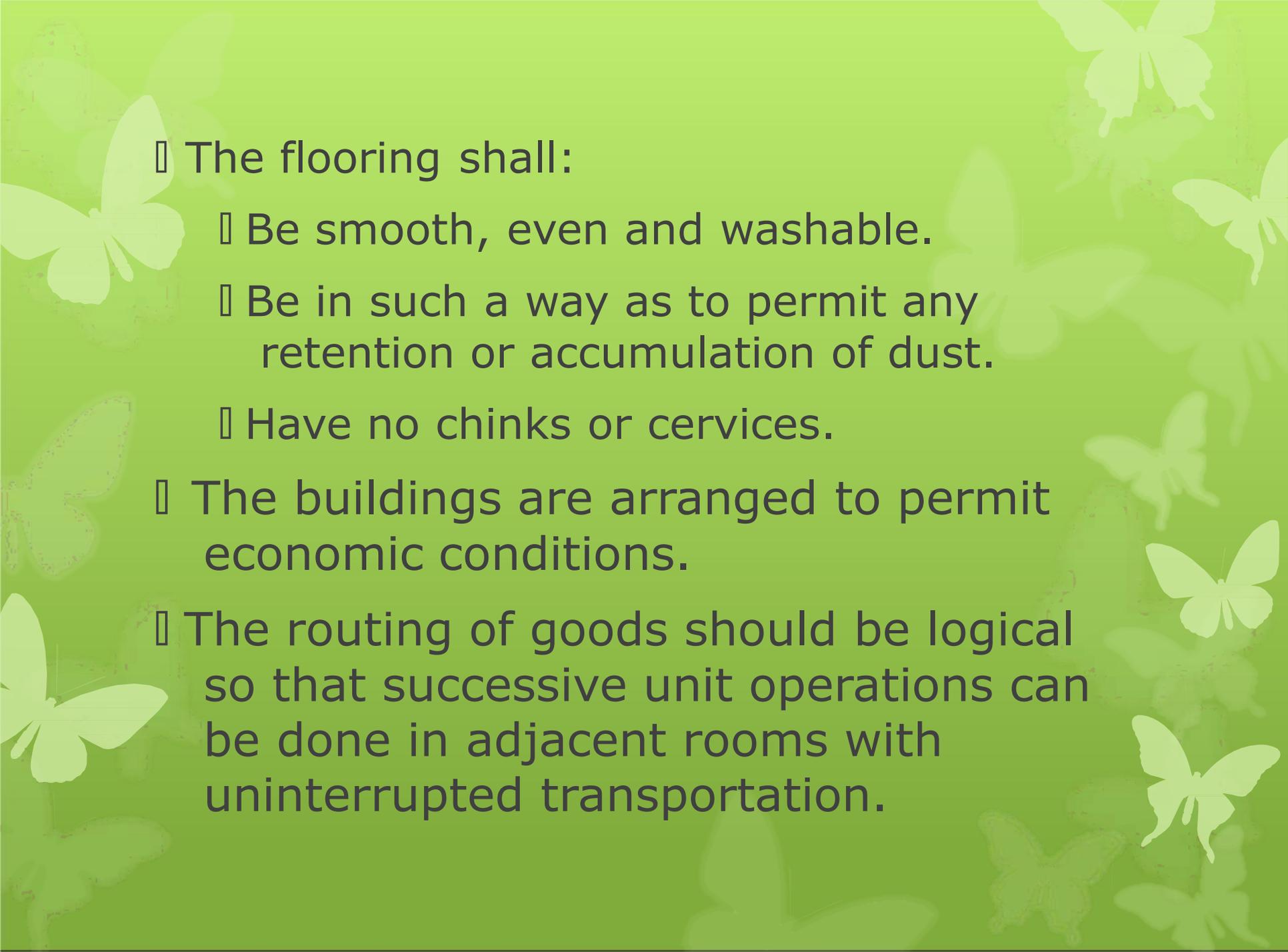
j) Auxillary equipment.

k) Possible future expansion.

# Some provisions of plant layout

- ▣ The premises should be suitable for the purpose of drug manufacturing.
- ▣ Measures should be taken to prevent mixing-up of substances or materials and contamination.
- ▣ The building of the factory shall be constructed so as to permit the production under hygienic conditions.
- ▣ They shall conform to the conditions laid down in Factories Act, 1948.

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- ▣ The part of the building used for manufacture should not be used as a sleeping place.
  - ▣ No sleeping place adjoining the building shall communicate therewith except through open air and through an intervening space.
  - ▣ The walls of the room in which manufacturing operations are carried out shall:
    - ▣ Have a height of 6 feet from the floor.
    - ▣ Be smooth and water proof
    - ▣ Be capable of maintaining cleanliness
    - ▣ Have no chinks or crevices



▣ The flooring shall:

▣ Be smooth, even and washable.

▣ Be in such a way as to permit any retention or accumulation of dust.

▣ Have no chinks or cervices.

▣ The buildings are arranged to permit economic conditions.

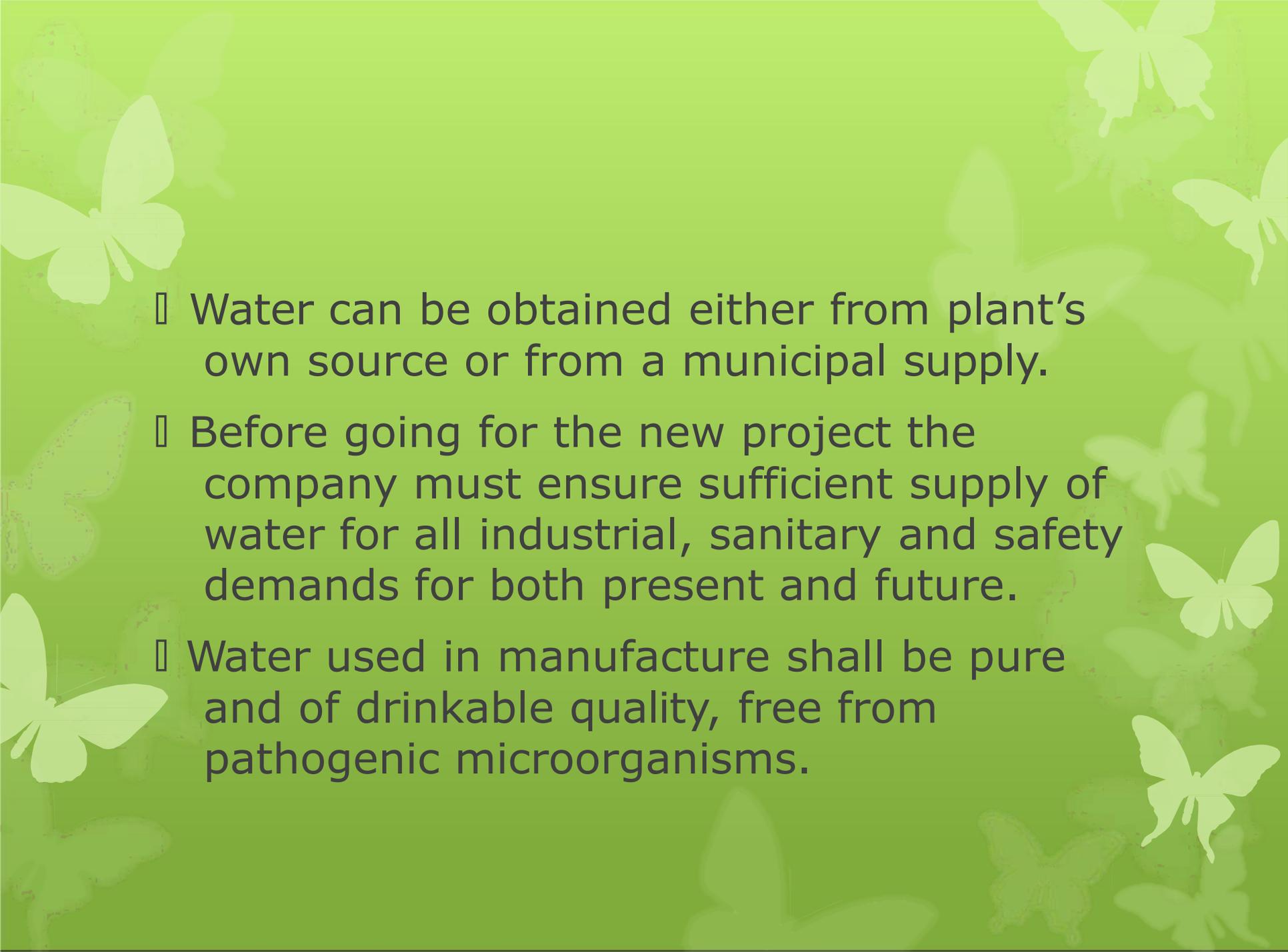
▣ The routing of goods should be logical so that successive unit operations can be done in adjacent rooms with uninterrupted transportation.

- ▣ Adequate facilities should be maintained to provide safety and fire protection.
- ▣ Regulations controlling escape routes in case of fires, providing fire fighting equipment, fire alarms and measures to be taken for prevention of breaking of fires and their spreading should be complied.
- ▣ Devices should be installed in every room where process operations are carried on, so that in times of emergency the power supply can be immediately cut off from the transmission machinery.
- ▣ Building meant for storing and handling should be segregated and isolated.

# Utilities and Services

## Utilities:

- Basic utilities: Power and Water
- Decision must be made on either to use purchased power or to set up its own power unit.
- Different methods to transmit power (mechanical energy, heat energy and pressure energy) and the best one to suit the particular process should be chosen.

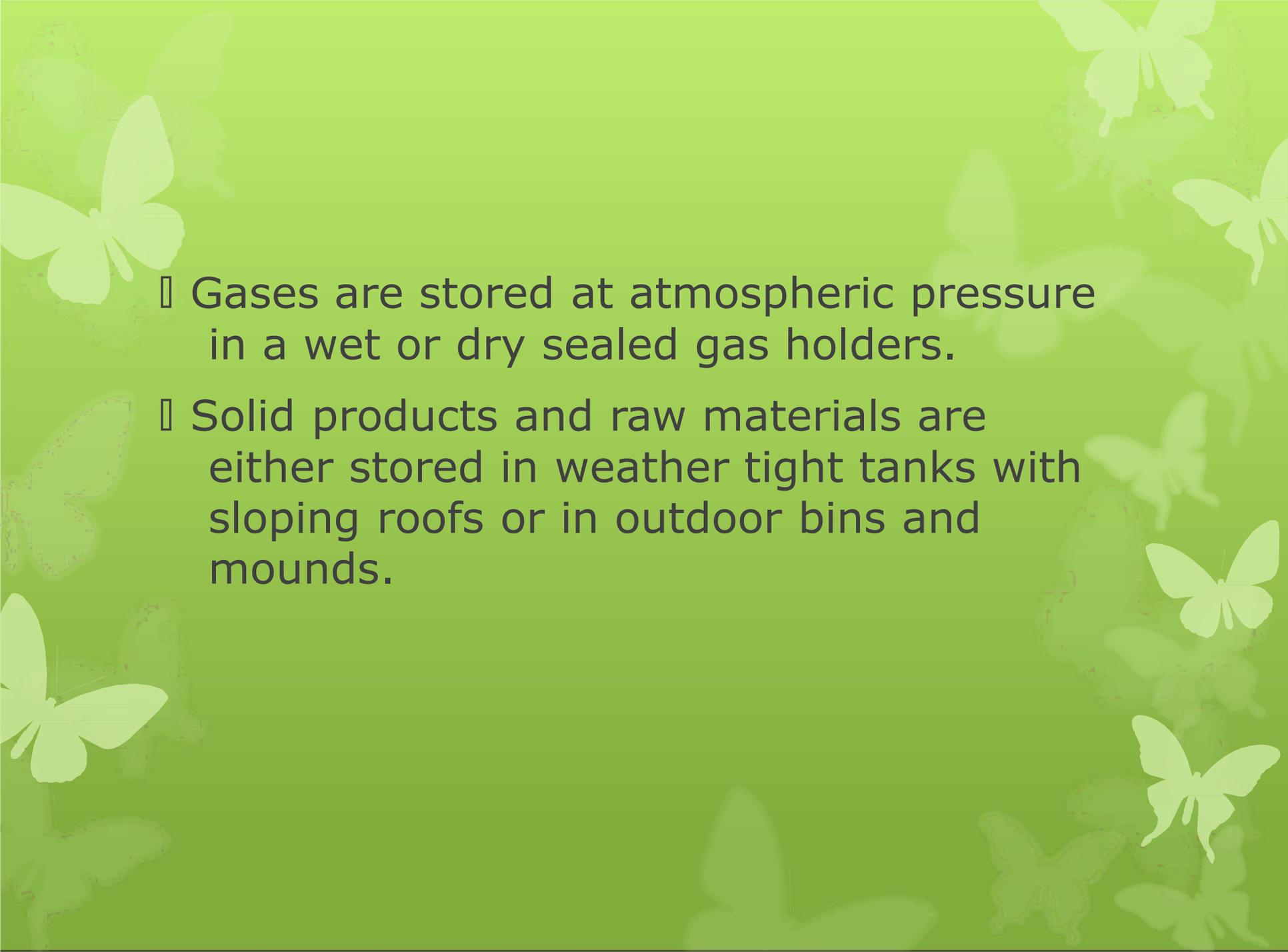
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- Water can be obtained either from plant's own source or from a municipal supply.
  - Before going for the new project the company must ensure sufficient supply of water for all industrial, sanitary and safety demands for both present and future.
  - Water used in manufacture shall be pure and of drinkable quality, free from pathogenic microorganisms.

## **Maintenance Services:**

- ▣ Sufficient space and facilities for maintenance work must be provided.
- ▣ Instruments to measure temperature, pressure and density are used.
- ▣ Automatic control systems are best.

# Storage:

- ▣ Adequate storage for raw materials, intermediates, recycle materials, rejected materials and fuels are essential.
- ▣ Bulk storage of liquids is generally handled by a closed cylindrical/ spherical tank so as to prevent the escape of volatile material and minimizing contamination.
- ▣ Liquids with vapour pressure above atmospheric pressure must be stored in vented tanks. Flame arrest mechanism must be installed in all the vents.

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- ▮ Gases are stored at atmospheric pressure in a wet or dry sealed gas holders.
  - ▮ Solid products and raw materials are either stored in weather tight tanks with sloping roofs or in outdoor bins and mounds.

# **Industrial Pollution and Control**

**Thermal pollution and control**

**Water pollution abatement**

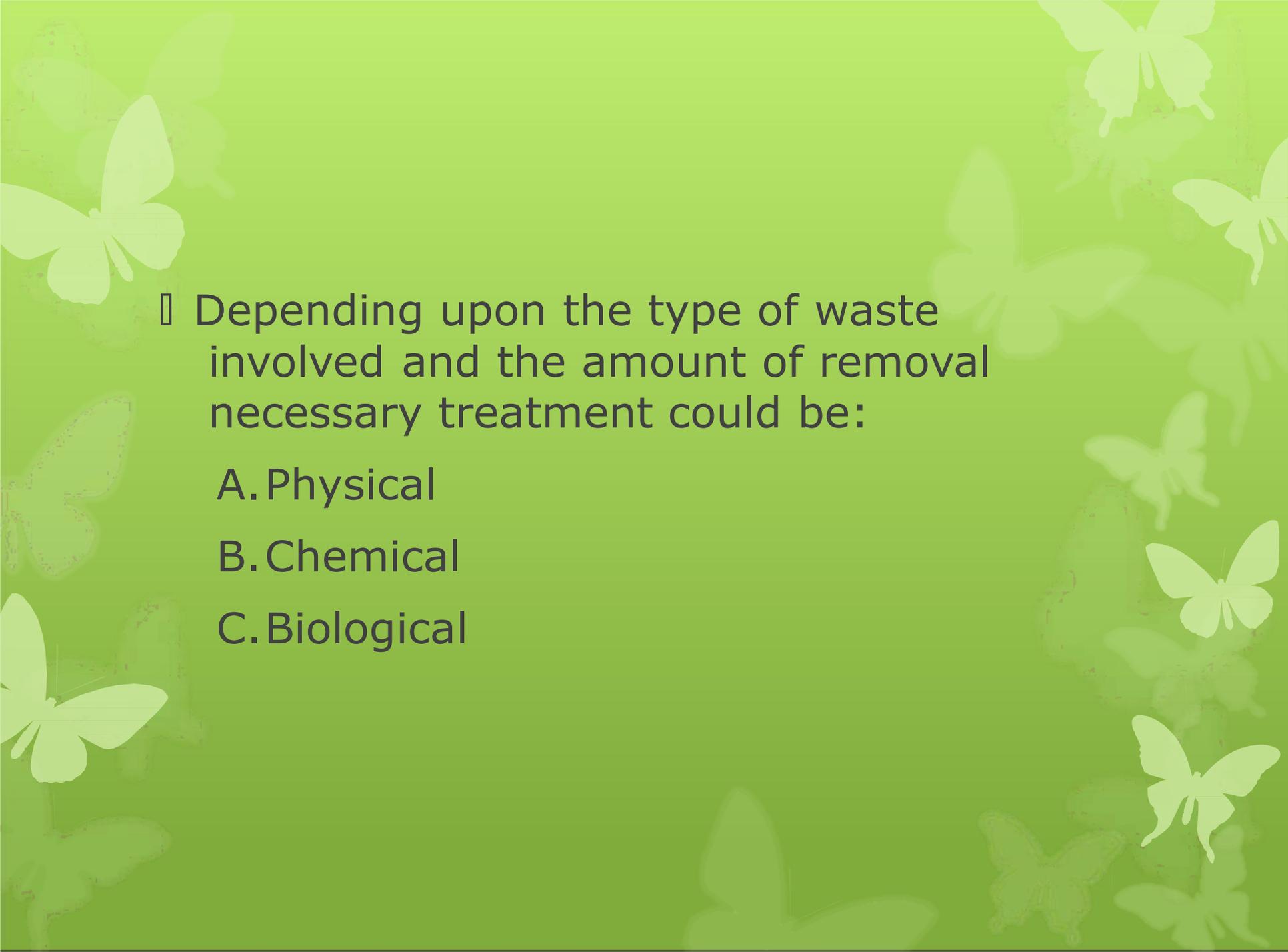
**Air pollution control**

# 1. Thermal Pollution Control:

- ▣ Various off-stream cooling systems are required to handle thermal discharges from processes because:
  - a. Changes in temp cause potential damage to the aquatic environment.
  - b. High temp causes reduction in the assimilative capacity of organic wastes.
  - c. Federal enactments are more stringent regarding water temp standards.

## **2. Water Pollution Abatement**

- More complex than handling a waste gas effluent.
- Waste liquid may contain dissolved gases/solids or it may be slurry in either conc. or diluted forms.
- Better to install recovery facility rather than waste treatment equipment.
- Best treatment process or combination of processes should identified.



□ Depending upon the type of waste involved and the amount of removal necessary treatment could be:

A. Physical

B. Chemical

C. Biological

## **A. Physical treatment:**

- ▣ Large floating or suspended particles are removed first.
- ▣ Methods: sedimentation and gravity settling methods.
- ▣ Adsorption process is employed using activated carbon for the removal of refractory organic substances, toxic substances and color.
- ▣ Ultrafiltration, reverse osmosis and electro-dialysis are used as the final treatment for the in-plant recovery systems.

## **B. Chemical treatment:**

- ▣ Used to remove colloidal matter, color, odour, acids, alkali, heavy metals and oil.
- ▣ Methods: coagulation, flocculation, emulsion breaking, precipitation and neutralization.

## **C. Biological treatment**

- ▮ If common bacteria are found in water, many organic materials will be oxidized to form carbon dioxide, water, sulphate and similar materials.
- ▮ This treatment consumes oxygen that is dissolved in water and may cause a depletion of dissolved oxygen.

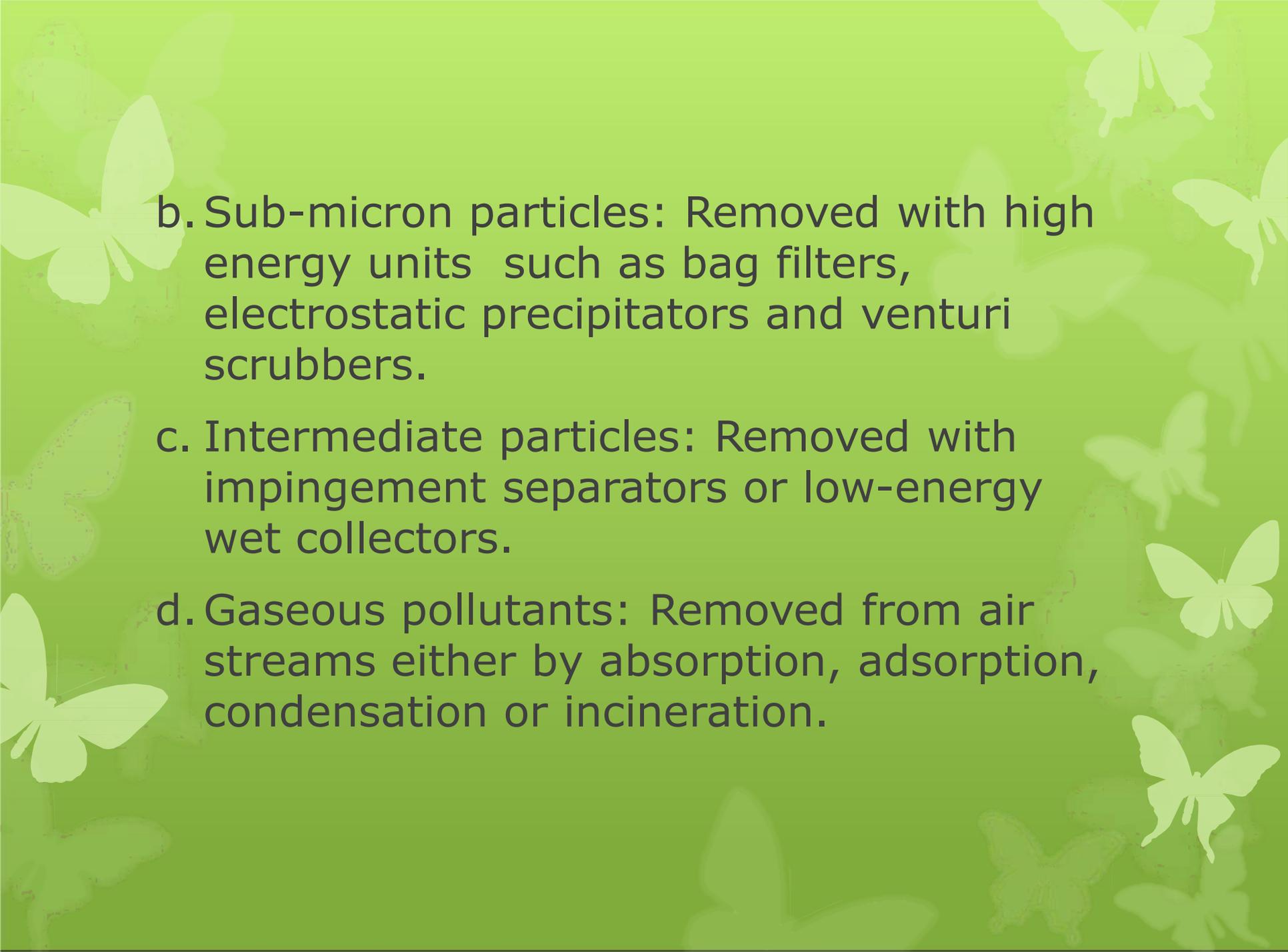
### **3. Air Pollution Control**

□ Classified into 2 categories:

- a. Those suitable for removing particulate matter.
- b. Those associated with removing gaseous pollutants.

□ Air pollutants can be removed in the following manner:

- a. For coarse diameter particulate: with low energy devices such as settling chamber, cyclones and spray chambers.

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- b. Sub-micron particles: Removed with high energy units such as bag filters, electrostatic precipitators and venturi scrubbers.
  - c. Intermediate particles: Removed with impingement separators or low-energy wet collectors.
  - d. Gaseous pollutants: Removed from air streams either by absorption, adsorption, condensation or incineration.

# **Industrial Hazard and Safety**

**Toxic and corrosive chemicals**

**Fire**

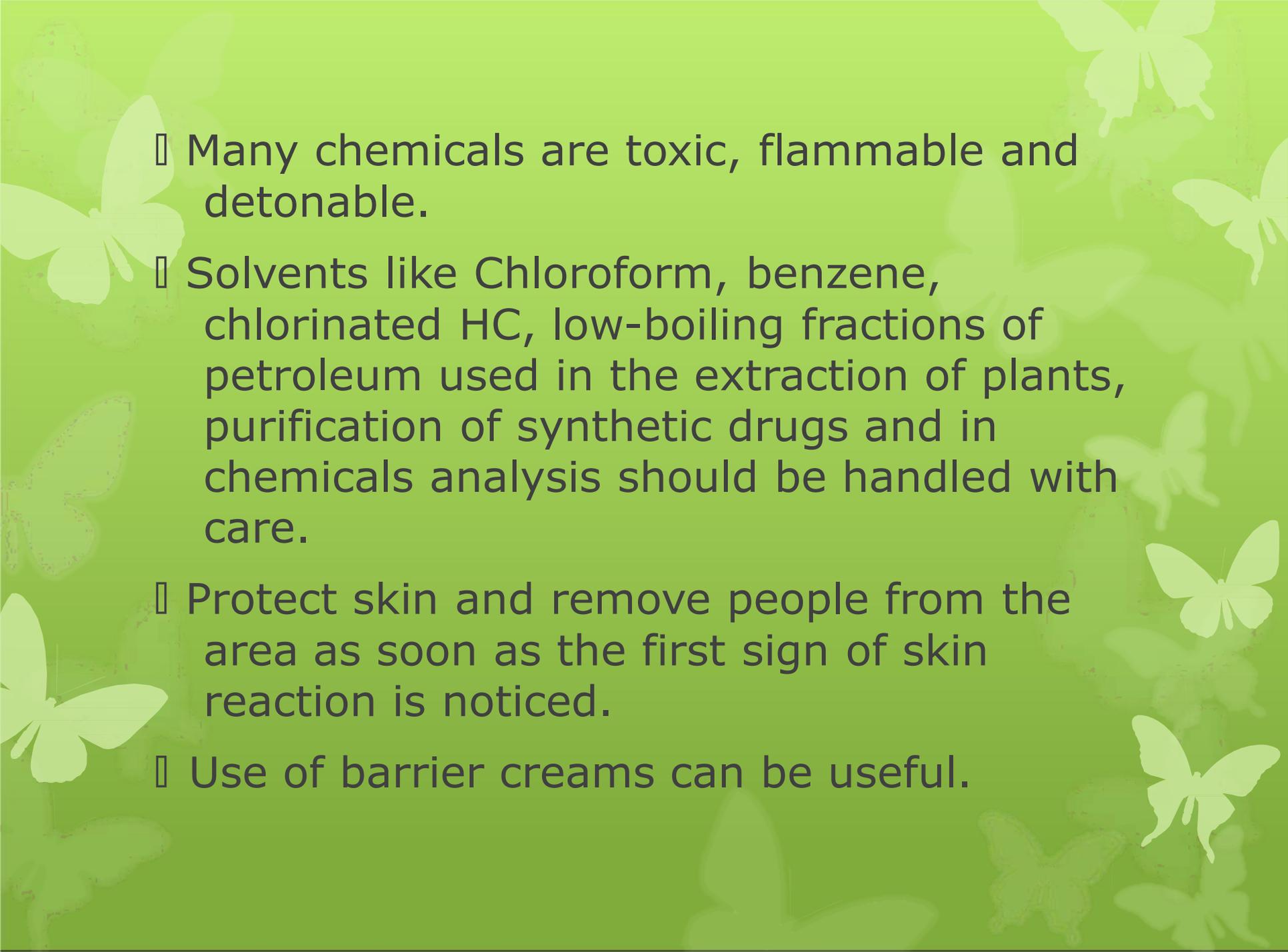
**Explosions**

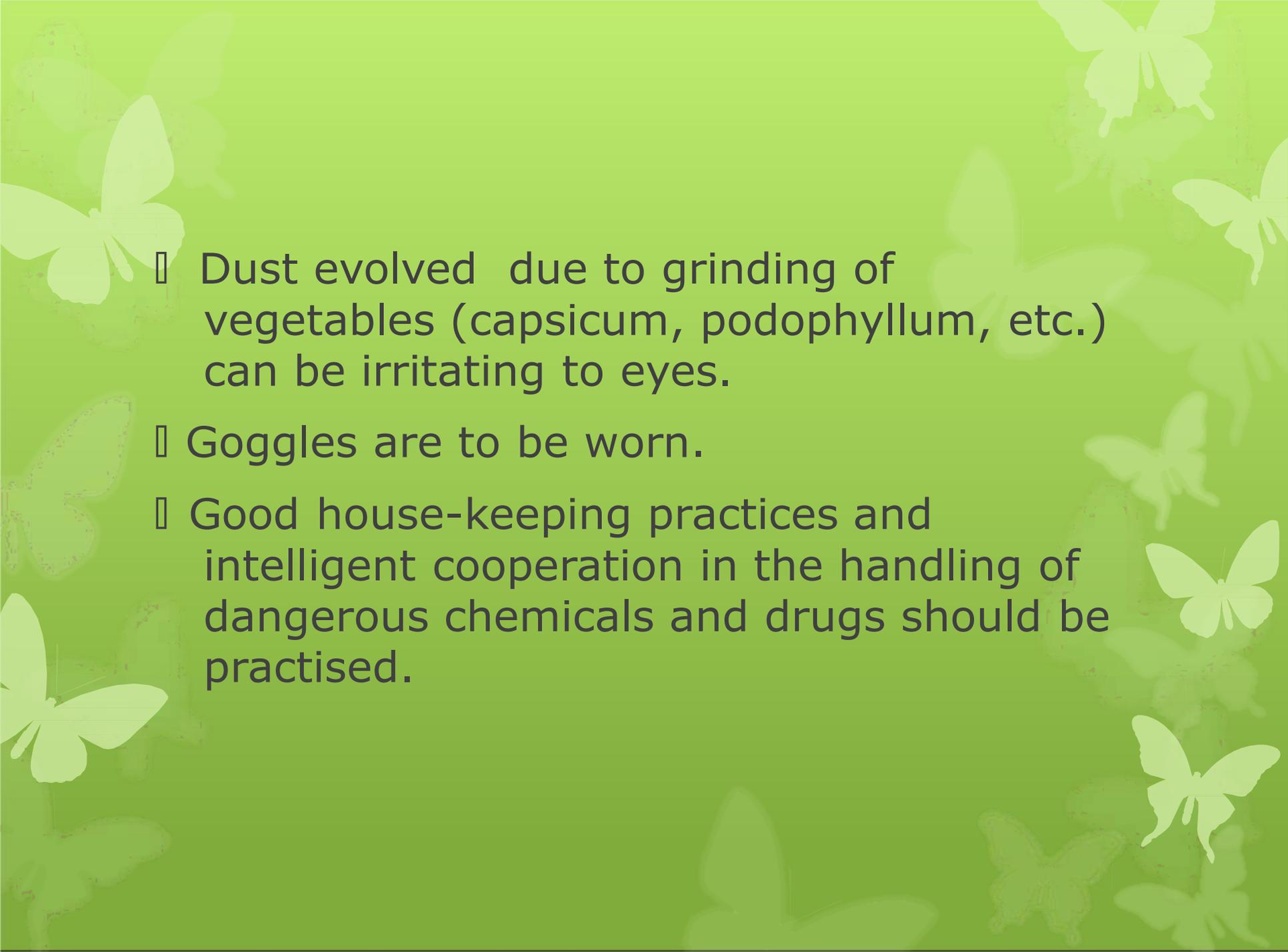
**Noise**

**Plant personnel**

# 1. Chemical hazards

- ▣ May bring about permanent impairment of health or even death.
- ▣ Chemical reactions with the tissue:
  - ▣ Dehydration by strong dehydrating agents.
  - ▣ Digestion by strong acids and bases.
  - ▣ Oxidation by strong oxidizing agents.
- ▣ Eyes and mucous membranes of the throat most susceptible to corrosive dust, mist and gases.

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- ▣ Many chemicals are toxic, flammable and detonable.
  - ▣ Solvents like Chloroform, benzene, chlorinated HC, low-boiling fractions of petroleum used in the extraction of plants, purification of synthetic drugs and in chemicals analysis should be handled with care.
  - ▣ Protect skin and remove people from the area as soon as the first sign of skin reaction is noticed.
  - ▣ Use of barrier creams can be useful.

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- ▮ Dust evolved due to grinding of vegetables (capsicum, podophyllum, etc.) can be irritating to eyes.
  - ▮ Goggles are to be worn.
  - ▮ Good house-keeping practices and intelligent cooperation in the handling of dangerous chemicals and drugs should be practised.

## 2. Dust Explosion

□ Methods to control dust:

a. Filtration

b. Inertial separation

c. Electrostatic precipitation

## **a. Filtration**

- ▣ Dust sucked through a mechanical barrier whose pore size is sufficiently small to retain the particles.
- ▣ Materials used: Paper, wool, cotton-wool and nylon.

## **b. Inertial separator**

- ▣ Separated by centrifugal force by circulating air in a spiral manner in a conical vessel (cyclone separator).

## **c. Electrostatic precipitators**

- Consists of a no. of earthed tubes.
- Fine metal wires are stretched between the tubes and high voltage is applied.
- High voltage ionizes the dust particles in the air and they thus deposit on metal plates which is collected periodically.

### **3. Fire and Explosion Hazards**

- Use of brick firewalls should be done.
- Roof is designed to lift easily under an explosive force.
- Adequate venting is necessary.
- Elimination of ignition sources like matches, welding, cutting, etc.
- Installation of fire alarms, temperature alarms, fire fighting equipment and sprinkler systems.

## 4. Noise abatement

- ▮ To attain efficient, effective and practical noise control, it is necessary to understand the noise sources, their acoustic properties and characteristics and how they interact to create the overall noise.
- ▮ E.g.- air coolers: fan blades, compressor: vibrations

## **5. Personnel Safety**

- Facilities for health and safety, protection of personnel in the plant design should be made.
- All machineries must guarded with protective devices.
- Medical devices and first aid must be readily available for all workers.

THANK  
YOU!