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B.Sc. CHEMISTRY

THIRD YEAR

PAPER - VIII : APPLICATION ORIENTED SUBJECT

PHARMACEUTICAL, INDUSTRIAL AND AGRICULTURAL CHEMISTRY

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APPLICATION ORIENTED SUBJECT

Pharmaceutical, Industrial and Agricultural Chemistry.

UNIT – I

1.1. Definition of the terms-drug, pharmacophore, pharmacodynamics, pharmacopoea, pharmacology, bacteria, virus, fungus, actinomycetes, metabolites, antimetabolites, LD50 and ED50.

1.2. Therapeutic index – their use in selecting drugs –Assay of drugs – various methods.

1.3. Antibiotics – Definition – Classification as broad and narrow spectrum antibiotics – penicillin, ciphalosporin, amphicillin, erythromycin – structure and mode of action only (no structural elucidation, preparation, assay)

UNIT – II

2.1. Analgesics – definition and action – narcotic and non-narcotics – morphine and its derivatives – pethidine and methodone – pharcological action – uses.

2.2. Antipyretic analgesics – salicylic acid derivatives – methyl salicylate, asprin, p-aminophenol derivatives – paraacetamol.

2.3 Antiseptics and disinfectants – definition and distinction – phelolic compounds – dyes – crystal violet, acridine, Chlorocompound – chlorhexidine, Cationic surfactants – Benzalkonium chloride, formaldehyde and nitrofurazone.

2.4 Anessthetics – definition – classification – local and general-volatile, nitrous oxide, ether, chloroform, cyclopropane –uses and disadvantages – nonvolatile – intravenous – thopental sodium, methohexitone, - local anaesthetics – cocaine and benzocaine.

2.5. Antianaemic drugs – iron, vitamin B 12 and folic acid – mode of action.

UNIT – III

3.1. Drugs affecting CNS – definition, examples for tranquilisers, sedatives, hypnotics and psychedelic drugs.

3.2. Hypoglycemic agents – sulphonyl urea, biguanides.

3.3. Cancer therapy – mode of action ofthiotepa, cyclophosphoramide.

3.4. AIDS – causes, prevention and control.

3.5. Indian medicinal plants and uses – tulasi, kilanelli, mango, semparuthi, adadodai and thoothuvalai.

3.6. Essential oils, isolation essential oils from plants. Production natural perfumes – flower perfumes – fruit flavours – artificial flavours.

3.7. Waxes, soaps and detergents – waxes – classification – some common waxes – manufactureof candles. Soaps and detergents – General consideration in soap making – manufacture of soaps and detergents – Action of soaps and detergents.

UNIT – IV

4.1. Water: Water treatment for domestic and industrial purpose.

4.2. Fuels: Calorific value – requirement of a fuel – types of fuels. Refining crude petroleum-octane number-antiknocking compounds – lead tetra ethyl.

4.3. Industrial gases: coal gas, producer gas, water gas, semi water gas, manufacture and industrial application, LPG – manufacture.

4.4. Bio-gas: Gobar gas – production, composition – Calorific value – renewable nature.

4.5. Industrial application – A brief treatment regarding composition manufacture and uses of synthetic fibres, rubber, paints and varnishes, glass, cement and ceramics.

UNIT - V

5.1. Fertilizers: Effect of Nitrogen, Potassium and Phosphorous on plant growth – commercial method of preparation of urea, triple superphosphate, Complex fertilizers and mixed fertilizers – Their manufacture and composition. Secondary nutrients – micronutrients – their function in plants.

5.2. Manures: Bulky organic manures – Farm yard manure – handling and storage. Oil cakes. Blood meal – fish manures.

5.3. Pesticides and insecticides: Pesticides – classification of insecticides, fungicides, herbicides as organic and inorganic – general methods of application and toxicity. Safety measures when using pesticides.

Insecticides: Plant products – Nicotine, Pyrethrin – Inorganic pesticides – borates. Organic pesticides – DDT and BHC.

5.4. Fungicides and Herbicides: Fungicide: Sulphur compounds, Copper compounds, Bordeaux mixture. Herbicides: Acaricides – Rodenticides. Attractants – Repellants. Preservation seeds.

Unit . I

1.1 Definition of the terms

1.1.1. Drug

A drug is any substance that alters normal bodily function.

A DRUG may be described as

1. substance that is used to modify physiological systems or pathological states;
2. any material used for the benefit of the patient.

E.g: tablets, vials and syrups etc.

Endogenous biochemicals are bodily secretions and drugs are foreign materials.

E.g: Insulin from Pancreas is a hormone; but when introduced into body, it is a drug.

1.1.2. Pharmacophore

A pharmacophore was first defined by Paul Ehrlich as "a molecular frame work carrying (*phoros*) the essential features responsible for a drug's (*pharmacon's*) biological activity"

Thus PHARMACOPHORE may be described as:

1. a functional group that imparts medical activity to a drug;
2. on removal may either reduce or destroy medicinal value.
3. introduction in a biologicallty inactive compound, makes it biologically active.

E.g: The following are the pharmacophore responsible for

1. Inhibitors of Thermolysin-amino-inhibitors.
2. Anti bacterial activity-sulphonamide.

1.1.3. Pharmacodynamics

Pharmacodynamics is the study of biochemical and physiological effects of drugs on the body or on microorganisms or parasites within or on the body and the mechanisms of drug action along with the relationship between drug concentration and effect.

Pharmacodynamics may be described as the study of what drug does to the body, i.e.

1. The response of living organisms to chemical stimulai in the absence of disease.
2. The informations on the use of specific therapeutic agent in the treatment. of diseases

E.g. drug-receptor interactions as modeled by: L + R ↔ L.R

L=ligand(drug), R=receptor (attachment site) and reaction dynamics by energy maps.

1.1.4. Pharmacopoea

Pharmacopoeia means the art of the drug compounder. It is an official code containing a selected list of established drugs and medicinal preparations, their physical properties and tests for their identity, potency and purity.

A few well known pharmacopoea are:

IP – Indian Parmacopoea; BP – British Parmacopoea; USP – Unites states Parmacopoea.

The following practical advantages are seen by Pharmacopoeia.

E.g.Doctor prescribes a medicine in generic name. The chemist makes the choice. Eg. Diclofenac: Any of the sixteen tablets and capsules available.

1.1.5. Pharmacology

Pharmacology is the science that deals with drugs.

PHARMACOLOGY may be described as a field comprising

1. drug composition, properties and antipathogenic capabilities.
2. interactions, toxicology, therapy and medical applications;

1.1.6. Bacteria

Bacteria are unicellular prokaryotic membrane bound autotrophic/heterotrophic organisms.

Bacteria may be described under the following parameters:

1. Thery are prokaryotic micro-organism;
2. Their membrane is madeup of unbranched fatty acids with glycerol by esters.
3. They are round, rod or spiral shaped.
4. They may be free living, saprophytic or parasitic.
5. They include mycoplasmas, cyanobacteria, Gram- positive and Gram-negative ones.

E.g.

1. Bacteria cause infections and diseases - *Mycobacterium tuberclosis* - Tuberclosis.

2. Some are useful making Chemicals, medicines etc - *Staphylococcus aureus* - penicillin.

1.1.6.1. Steps to identify gram +ve, -ve and variable bacteria.

Grams stain is a reagent and it is a mixture of crystal violet and Iodine. Depending on the thickness and chemical composition of the cell wall, it stain bacteria.

The procedure with 4 steps are followed:

1. The air-dried and fixed bacterial smear is covered with crystal violet for 30 seconds.
2. The slide is rinsed with water and the smear is covered with Gram's Iodine for 30 sec.
3. It is washed with water and decolorized with ethanol
4. It is counterstained with safrannin for 1 min., rinsed with water, dried and examined.

Gram-positive *bacteria retain the purple color of crystal violet - Staphylococcus aureus.*

*In G**ram-negative** purple color is removed; stain red by safranin - Neiseria meningitidis.*

Gram variable bacteria are neither consistently purple, nor red- *Mycobacterium tuberclosis.*

1.1.7. Virus

Viruses are submicroscopic obligate parasites, capable of reproducing inside other cells. Bawden.1949 and Luria.1953.

VIRUSES may be described under the following parameters:

- Viruses are not cells and do not have a cell membrane or cell components.
- Living host cells are needed for their reproduction and outside they act as nonliving.
- They do not metabolize or respond to stimuli.
- They have genetic material and can mutate and evolve.
- They form parasitic relationships with living organisms.

E.g. Hepatitis A virus (HAV) – Liver damage; Reteroviruses – HIV (Aids)

1.1.8 Fungus

Fungi are multicellular (yeast-unicellular) heterotrophic organisms with two nuclei per cell

FUNGI may be described in the following parameter:

- They are neither plant nor animal, but are sessile.

- They do consume organic matter, have no chlorophyll.
- They have a true nucleus in their cells.
- They are able to reproduce both sexually and by spores.

E.g.: *Aspergillus fumigatus*- the infection leads to chronic lung disease and may cause death.

1.1.9. Actinomycetes

Actinomycetes are prokaryotic, aerobic, gram-positive bacteria.

ACTINOMYCETES may be described as follows:

- They assemble themselves in branching filaments and produce spores.
- They are primarily found in soil and break down organic compounds.
- Their secondary metabolites are used as drugs.

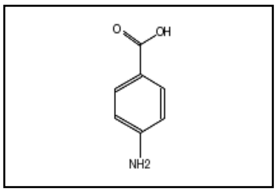
E.g. Erythromycin is produced by *Streptomyces erythreus*..

1.1.1 Metabolites

Metabolites are the intermediates or end products of metabolism.

A primary metabolite is directly involved in the normal growth, development, and reproduction of an organism.

A secondary metabolite is not directly involved in those processes, but usually has important ecological function.



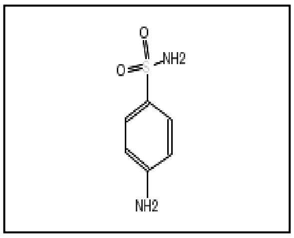
E.g.: Metabolite PABA – p-aminobenzoic acid

1.1.11 Antimetabolites

Antimetabolites resemble metabolite in structure but metabolically inactive.

ANTIMETABOLITES may be described as follows:

1. These molecules resemble a substrate/metabolite.
2. They are metabolically inactive.
3. These substances are used as a drugs.



E.g.: Antimetabolite - Sulphonamide - p-aminobenzene

1.1.2 LD50

The median lethal dose, **LD_{50}** is the dose in (mg/Kg) which would be expected to kill one half of an unlimited population of the same species and strain.

The median lethal dose, **LD_{50}** may be expressed as:

"Lethal Dose, 50%" , "The Median Lethan Dose" or LCt_{50} (Lethal Concentration & Time) of a toxic substance/radiation that is the dose required to kill half the members of the tested population (of same species and strain) The test was created by J.W. Trevan in 1927.

1.1.3 ED50

The median effective dose**, ED50** is the dose (mg/Kg) which produces a desired response in 50 per cent of test population.

The median effective dose**, ED50** may be detailed as:

EFFECTIVE DOSE is the minimal dose that produces the desired effect of a drug (Pharmacology) and "EFFECTIVE DOSE, 50%" is often determined based on analysing the dose-response relationship specific to the drug.

1.2 Therapeutic Index

1.2.1 Therapeutic Index – Calculations

The therapeutic index (therapeutic ratio) is a comparison of the amount of a therapeutic agent that causes the therapeutic effect to that of the toxic effects.

The therapeutic index may be described as

1. Quantitatively the therapeutic index is the ratio given by the dose required to produce the toxic effect divided by the therapeutic dose.
2. Therapeutic index may be measured by the lethal dose of a drug for 50% of the population (LD_{50}) divided by the minimum effective dose for 50% of the population (ED_{50}) of the same species of the same environment.

$$\text{Therapeutic index (TI)} = \frac{LD_{50}}{ED_{50}}.$$

In general, the narrower this margin, the more likely it is that the drug will produce unwanted effects.

Exceptions.

- Generally, a drug with a narrow therapeutic range may have its dosage adjusted according to the actual blood level achieved by the patient.
- When chemotherapy or radiotherapy is infused or injected, in leverage of targeting, the delivery ratio can be much higher without any change in the therapeutic index.

1.2.2 Use of “Therapeutic index” in the selection of drugs.

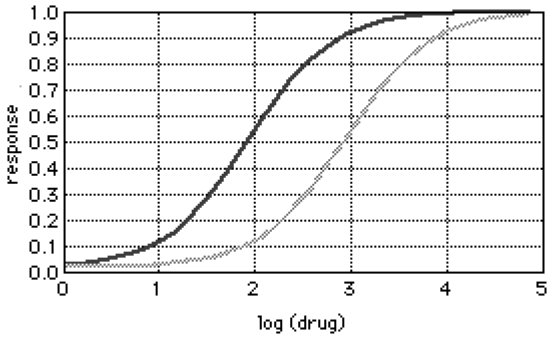
The ratio of the drug dose which produces an undesired effect to the dose which causes the desired effects is a therapeutic index and indicates the selectivity of the drug and consequently its usability (Higher the index, better for selection)

A single drug can have many therapeutic indices, one for each of its undesirable effects relative to a desired drug action, and one for each of its desired effects if the drug has more than one action. (Relative estimation and Specific selection is good)

Both the positioning and the slope of the cumulative frequency distribution curves for the desired effect and for the side effects/toxic effects/lethal effect are the indicators of safety of the drug and the ability to use the drug successfully. (Statistically estimated Cumulative frequency is the best index for the successful use of drug)

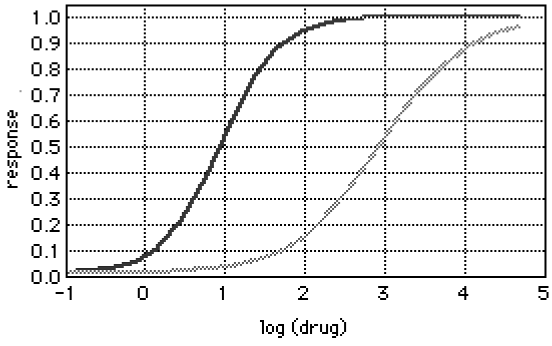
The important factor is to have graphically a clear gap between the maximum dose required to produce therapeutic effect and minimum dose required to produce undesirable side effects. (The high the gap or bay between the curves, safer the patient on the specific dose)

E.g: Lower the therapeutic index, lesser the chance of selection.



The relativity can be well identified by the distribution curves and the difference in bay.
Desired effect:-100-dark
Toxic effect:-1000-light
Therapeutic index:-10

E.g: The larger the therapeutic index, the safer is the drug.



n = the steepness of the slope.
n > 1 is steeper than normal
n < 1 is shallower than normal
ED50-n
Desired effect:-10-1.2-dark
Toxic effect:-1000-0.8-light
TD50/ED50:-100

Ti of Penicillin is 100, indicating that the drug is relatively safe in terms of toxic effects of overdosage. On the contrary,Digoxin has a rather low Ti of 1.5 to 2.0 (less than 10) and the margin of safety is narrow.

All promising new compounds are subjected to pharmacokinetic studies (Absorption, Distribution and Elimination studies) in several species of animals. The data obtained on animals must be applied to humans very cautiously. Human Biotransformation is another critical evalution wherein the elimination of the drug should be confirmed first.

1.2.3 Assay of drugs

Assay is the estimation of potency of an active principle in a unit quantity of the drug. Potency is the measure of the biological activity of a drug. There are three main types:

1. Chemical assay;
2. Biological assay; and
3. Immunological assay.

1.2.4 Various methods of Assay.

1.2.4.1. Chemical assay

In the chemical assay the concentration of the active principle of the drug is estimated with the help of chemical methods.

Functional methods.

Depending upon the nature of the functional group present in the drug and its chemical properties, various chemical methods can be adopted. They are titrometry, other chemical methods or instrumental methods. Here active principle group (e.g. amino group) is estimated. The instrumentation methods are used for they are rapid, and require smaller quantities of substances and can be readily compared with standards.

E.g.: (a) Titrometry

The drug having carboxyl group can be estimated by direct titration with an alkali;

The drug having hydroxyl group or amino group can be estimated by acetylation;

E.g.: (b) Other chemical methods

The drug with/having salicylate, sulphanamides, narcotic analgesics and penicillin or amino group can be estimated by acetylation, iodometry etc.,.

E.g.: (c) Instrumental methods

These methods are Spectrophotometry, Fluorometry, High pressure gas chromatography, Mass spectrometry, High pressure liquid chromatography and Photometry.

1.2.4.2. Biological Assay.

Biological assay of drug is the determination or estimation of the amount of biological activity in a unit quantity of drug in the tested organism.

Bioassay is resorted to under the following conditions:

1. When the chemical composition is not known but the substance has specific action. E.g.: Long acting thyroid stimulator (LATS).
2. When there is no simple chemical assay procedure.
3. When chemical assay is too complex or insensitive. (E.g.: Adrenaline can be bioassayed in microgram quantities).
4. When drugs with different composition having the same activity are to be analysed. (E.g.: Digitalis glycosides obtained from different sources).
5. When active principle cannot be isolated easily or decompose during isolation. (E.g.:peptide hormone).
6. Although the biological response are variable, bioassay may be programmmed to any degree of accuracy by repeated tests and inferred by statistical interpretations.

Bioassays of drugs may be described as:

1. Bioassays are conducted to measure the effects of a substance on a living organism.
2. Bioassays estimate the pharmacological activity of new/chemically undefined ones.
3. They are used in the investigation of the function of endogenous mediators.
4. The are used to determine the side-effect profile and the degree of drug toxicity.
5. Assessing the amount of pollutants being released by a particular source.

Functional methods of Bioassay.

1. They may be **qualitative or quantitative**
    a. Qualitative bioassays are used for assessing the physical effects of a substance such as abnormal development or deformity.

    b. Quantitative bioassays involve estimation of the concentration or potency of a substance by the measurement of biological response that it produces; eventually estimation are analyzed by biostatistics.

2. Bioassay methods measure the crude sample of a drug by studying the effect on animals, either singly or in groups, or on tissues. They may be **direct or indirect**.
    a. Direct comparison on the same tissues is done by the investigation that is compared with the standard (control).
    b. Direct assay on several animals is done by treating with several doses in increasing amounts of drug preparation. Finally the minimum concentration required for positive response from 50% of animals is determined both for unknown and standard (control). Eventually the unknown is calculated.

$$C = \frac{ED_s\,(50)}{ED_u\,(50)} \times \text{Conc. of standard.}$$

Where ED_s (50) = Effective dose for 50 per cent with standard; and

ED_u (50)= Effective dose for 50 per cent with unknown.

    c. In indirect assay method the potency of a drug is determined by comparing

    the log dose-reponse curve of the unknown with that of the standard.

1.2.4.3. Immunological assay.

Immunological assay gives the extent of immunity imparted by a the drug to an antibody.

Immunological assay of drugs may be described as:

1. It is mainly used for estimating the potency of certain hormones.
2. It depends on the chemical reaction of hormone antigen and its antibody.

Functional methods of immunological assay.

1. In this method labelled hormone is allowed to compete with unlabelled one and eventually the inhibition of the labelled hormone and activities of free unlabelled hormone are tabulated to estimate B/F ratio. Data of standard preparation is plotted to identify the unknown **quality/quantity of hormones**.

2. It is well used for the comparative estimation **of plasma concentrations of various hormones, biochemicals and drugs.**

1.3 Antibiotics

1.3.1. ANTIBIOTICS

Antibiotics are chemical substances that are produced by microorganisms and that inhibit the growth of other microorganisms or destroy.

An ANTIBIOTIC may be described as follows:

1. It is a chemotherapeutic agent that inhibits/abolishes the growth of microorganisms.
2. Previous treatment was any agent such as strychnine and arsenic, with high toxicity and biological activity against living organisms. But present antibiotics from microbes have no or few side effects and have effective target activity.
3. Previous treatments were for all infections and problems based on activity, but now antibiotic is used to refer anti-bacterial specifically.

E.g.:The first widely used antibiotics in modern medicine were produced and isolated from living organisms (fungi *Penicillium* or bacteria *Streptomyces)*. Presently many antibiotics are obtained that are relatively small molecules with less molecular weight-2000 Da. However most anti-bacterial antibiotics do not have activity against viruses, fungi or others.

1.3.2 Classification of antibiotics:

Antibiotics are classified on their target specificity:

1. The **Broad-spectrum** antibiotics affect a wide range of disease-causing bacteria. (against both Gram-positive and Gram-negative bacteria).
2. The **Narrow-spectrum** antibiotics target particular types-Gram-negative or Gram-positive bacteria. (against only specific families of bacteria).

Broad-spectrum antibiotics are to be used as follows:

1. usually prior to identifying the causative bacteria,
2. when differential and potentially high illness occur,
3. when illness lead to delay of treatment and death,
4. in super-infections with multiple types of bacteria.

E.g.: in meningitis, when patient becomes serious, broad-spectrum(Levofloxacin) is initiated

Narrow-spectrum antibiotics are to be used as follows:

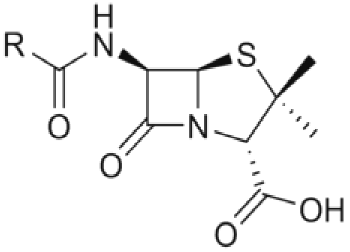
1. when drug resistant bacteria do not respond to other, narrow-spectrum antibiotics are to be used.
2. ideally, the spectrum should be "narrowed down" by identifying the causative agent of an infection.
3. to limit the development of antibiotic resistance replacing broad-spectrum to narrower-spectrum antibiotic is essential.

E.g.: The narrow spectrum penicillins - benzylpenicillin.

1.3.3 Penicillin

Pencillin, with the antibacterial property, was discovered by Alexander Fleming in 1920 (Nobel Prize for Medicine in 1945). Benzylpenicillin – of Penicillin, basically the narrow spectrum antibiotic -derived from *Staphylococcus aureus.* "Penicillin" is also the informal name of a specific member of the penicillin group Penam Skeleton, which has the molecular formula R-$C_9H_{11}N_2O_4S$, where R is a variable side chain.

1.3.3.1. Structure



Core structure - Benzathine - benzylpenicillin (rINN)

1.3.3.2. Mechanism of action

- The antibiotic causes cytolysis due to higher osmotic pressure to the bacteria.
- β-lactam antibiotics, Penicillin, work by inhibiting the formation of peptidoglycan cross-links in the bacterial cell wall.
- It also builds-up peptidoglycan special precursors and triggers the activation of bacterial cell wall hydrolases and autolysins and digest the cell wall.
- After treatment with penicillin, Gram-positive bacteria become protoplasts (without cell wall) Gram-negative bacteria become spheroplasts (with incomplete cell wall)
- Since penicillin has a synergistic effect with amino- glycosides, it penetrate the damaged bacterial cell wall and disrupts the bacterial

protein synthesis to make lower MBC (minimum bactericidal concentration).

1.3.3.3. Adverse drug reactions

I. Common adverse drug reactions (≥1%)-diarrhea, nausea, rash, urticaria, superinfection.

II. Some Infrequent adverse effects are - fever, vomiting, erythema, dermatitis, angioedema, seizures and pseudomembranous colitis.

III. Allergy/hypersensitivity are common; Pain and inflammation at the injection site is seen.

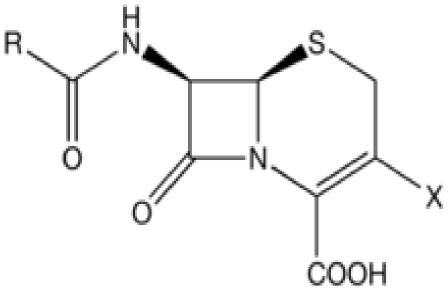
1.3.3.4. Uses

PENICILLIN (abbreviated PCN) is a group of beta-lactam antibiotics used in the treatment of bacterial infections caused by susceptible, usually Gram-positive, organisms.

Cephalosporins

Cephalosporins are β-lactam antibiotics and with cephamycins they belong to cephems. Cephalosporin compounds were first isolated from cultures of *Cephalosporium acremonium* from a sewer in Sardinia in 1948 by Italian scientist Giuseppe Brotzu.

1.3.4.1. Structure



Cephalosporin nucleus

1.3.4.2 Mode of action

Cephalosporins are bactericidal and have the same mode of action as other beta-lactam antibiotics (such as penicillins). Cephalosporins disrupt the synthesis of the peptidoglycan layer of bacterial cell walls. (disrups the final transpeptidation step by inhibiting/mimic act on transpeptidases, penicillin binding proteins-PBPs). β-lactam antibiotics mimic this site and bind to D-Ala-D-Ala at the end of muropeptides (peptidoglycan precursors) to inhibit PBP crosslinking of peptidoglycan.

1.3.4.3. Adverse reactions

I. Common adverse drug reactions - diarrhoea, nausea, rash, urticaria, superinfection.

II. Some infrequent adverse effects are - fever, vomiting, dermatitis and angioedema.

III. Pain and inflammation at the injection site is seen.

1.3.4.4. Uses

The cephalosporin antibiotic is effective against *Salmonella typhi,* of typhoid.

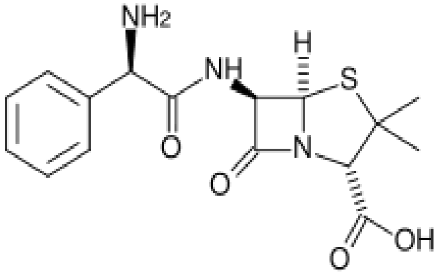
The cephalosporin nucleus can be modified to gain different properties. These are grouped into "generations" by their antimicrobial properties and different group activities. They are

1. On methicillin-susceptible *staphylococci, streptococci* and against *Escherichia coli.*
2. With greater activity on Gram-negative spectrum.
3. A broad spectrum of activity and also increased activity against Gram-negative organisms.
4. Effective in meningitis and used against *Pseudomonas, Cefipime and Cefoperazone*

1.3.5. Ampicillin

Ampicillin is a beta-lactam antibiotic, a part of the aminopenicillin family and is equivalent to amoxicillin in terms of spectrum and level of activity and used for treatment from 1961.

1.3.5.1. Structure



Ampicillin

1.3.5.2. Mode of action

1. Ampicillin acts on Gram-positive and some Gram-negative bacteria.
   (a) The fused β-lactam structure, - this is responsible for high Gram-positive bacterial penitration due to the continuous –C-CO-NH-C-CO-N-C-COO- linkage.

(b) The carboxyl group – ansorption and the biological activity depends upon the stereochemistry specifically carbon atom with carboxyl group in D configuration.

(c) The amino group side chain in hydrophilic – facilitates the stability of the drug towards acids and the penetration of outer membrane of gram-negative bacteria.

2. Amphicillin acts on both Gram-positive and some Gram-negative bacteria, inspite of reduced activity on gram-negative due to the addition of a second substitution in the bezene ring, for the hydroxyl group at meta or para positions balances the activity.
3. Amphicillin acts with high intensity in antibacterial activity because of the amide carrying carbon atom (C_6) is in L configuration facilitates competitive inhibitor of the enzyme transpeptidase (needed by bacteria to make their cell walls).
4. Amphicillin derivatives mostly function as pro-drug for the antibiotic; they have extra-side chains amino groups; these adducts provide cover for Group A infections

1.3.5.3. Adverse drug reactions

1. It can sometimes result in allergic reactions i.e. from a rash (e.g. patients with mononucleosis) to potentially lethal anaphylaxis

1.3.5.4. Uses

Ampicillin is closely related to amoxicillin, another type of penicillin, and is used to treat:

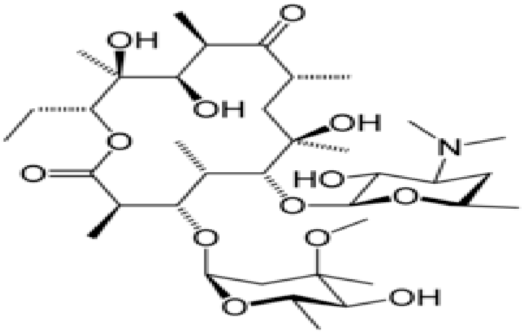
(a) Urinary infections, meningitis, pneumonia, Haemophilus influenza, salmonellosis etc.

(b) Along with flucloxacillin in the combination antibiotic co-fluampicil for cellulitis;

Erythromycin

Erythromycin is a macrolide antibiotic that has a wide antimicrobial activity than penicillin, and is used for patients with allergy to penicillins. It is produced from a strain of actinomycete *Saccharopolyspora erythraea*. It is available in enteric-coated tablets, capsules, oral suspensions, ophthalmic solutions, ointments, gels and injections.

1.3.6.1. Structure



It contains a 14-membered lactone ring with ten asymmetric centers and two sugars (L-cladinose and D-desoamine).

Erythromycin

1.3.6.2. Mode of action

Erythromycin may possess bacteriocidal activity at higher concentrations. By binding to the 50S subunit of the bacterial 70S rRNA complex, protein synthesis and subsequently structure/function processes critical for life or replication are inhibited. Erythromycin interferes with aminoacyl translocation, preventing the transfer of tRNA from A site of ribosome complex to P site. Eventually addition of amino acid to nascent polypeptide chain is inhibited. Thus the production of proteins is inhibited to achieve antimicrobial action.

1.3.6.3. Adverse effect

1. Erythromycin inhibits the cytochrome P450 system to affect metabolism of many drugs.
2. When taken concomitantly with simvastatin, etc., leads to simvastatin - rhabdomyolysis.
3. Gastrointestinal disturbances, diarrhea, nausea, abdominal pain and vomiting are seen.
4. Allergic reactions like urticaria to anaphylaxis may occur; arrhythmia,deafness are rare.

1.3.6.4. Uses

1. It covers atypical organisms of respiratory tract infections(mycoplasma, legionellosis etc)
2. It is also used to treat outbreaks of chlamydia, syphilis, acne, and gonorrhea.
3. Erythromycin may be useful in treating gastroparesis due to this pro-motility effect.
4. Intravenous erythromycin may be used in endoscopy as an adjunct to clear gastric content

NOTES

Unit - II

2.1. ANALGESIC

2.1.1. An analgesic (known as a painkiller) is any member of the diverse group of drugs used to relieve pain (Greek:an="without" –algia="pain"). Analgesic drugs act on peripheral and central nervous systems to cause insensitivity to pain without loss of consciousness.

2.1.2. Action of Analgesics

The main function of analgesics is to relieve or decrease the sensation of pain. The pain is usually induced by a stimulus and the amount of stimulus may be regarded as a measure of the threshold of pain.

Analgesics act by:

1. increasing the threshold of pain that is the lowest perceptible intensity of pain.
2. increasing the threshold of pain, the pain is high but the patient does not feel pain.

2.1.3. Classification based on the norcotic action.

Though the classification of analgesics as Narcotic (or strong) and non-narcotic(or weak) is not used now, this was the basic way of classifying analgesics. Presently both are considered to be strong analgesics with specific variation in action.

Strong Analgesics:

2.1.3.1. Narcotics:

A drug that produces

1. analgesia (pain relief) and narcosis (state of stupor or sleep).
2. addiction (physical dependence on the drug).
3. euphoria-(feeling of great elation)-depression in CNS.

They include

a. Natural opium alkaloids.(Morphine, codeine).
b. Semisynthetic derivatives of natural opium alkaloids. (heroin, dihydromorphinone).
c. Synthetic morphine substitures.(pethidine,methadone)

2.1.3.2. Non – narcotics:

Drugs that are analgesic, antipyretic, anti-inflammatory and do not bind to opioid receptors.

1. Inactivate thalamic and hypothalamic sites of the integration of pain sensation.

2. Inhibit the formation of prostaglandin cell membranes by irreversible acetylation and thereby inactivate prostaglandin synthetase, (pain expressing enzyme)

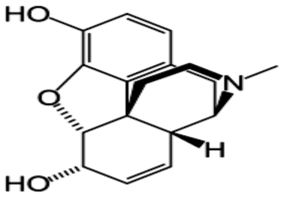
They include

a. tetrahydro isoquinolines
b. benzylamines
c. some compounds similar to opiates – like Tilidine

2.1.4. Narcotics

2.1.4.1. Morphine

Morphine is a highly-potent opiate analgesic drug and is the principal active agent in opium and the prototypical opioid. It is isolated from the unripe seed capsules of the poppy *'Papaver somniferum'*. Morphine occurs in opium in concentrations varying from 5 to 20%. The word "morphine" is derived from Morpheus, the Greek god of dreams. Morphine as free alkaloid is an odourless white cystalline substance with a bitter taste. It is insoluble in water and soluble in alkaline solutions because of its phenolic group. It forms readily watersoluble salts with most acids. The preferred form used in medicine are the sulphate and hydrochloride. The usual dosage is 2 to 20 mg.



Morphine

Pharmacological action of MORPHINE.

1. Morphine acts directly on the central nervous system.
2. Morphine raises the pain threshold thereby reducing the perception of pain.
3. It produces a sense of emotional well being euphoria.
4. Eventually euphoria eliminates the normal fear, panic and aids the analgesic action.

Adverse reactions

- addictive- tolerance, physical and psychological dependences.
- produces- constipation, dryness of mouth, mental clouding,
- nausia, head ache, fatigue and pruritus (itching).
- induces- depression of respiration, vomitting and miosis.

Uses

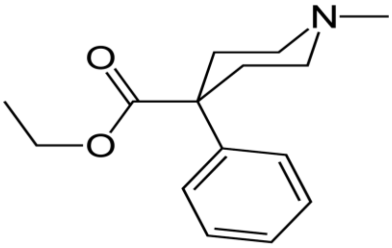
1. Relief of pain-to alleviate severe pain conditions (myocardial infarction, fractures, burns).

2. Valuable sedative in the presence of pain.

3. Pre-anaesthetic medication.

2.1.4.2. Pethidine

Pethidine or meperidine (isonipecaine lidol; pethanol; piridosal) is a fast-acting opioid analgesic drug. It was empirically discovered in 1939 by Eiselb and Schaumann. It is delivered as hydrochloride salt in tablets, syrups or intramuscular or intravenous injection.



Pethidine

Pethidine exerts its analgesic effects as morphine.

1. It acts as an agonist at the μ-opioid receptor
2. It has strong opiodergic and anticholinergic effects.
3. It has local anesthetic activity related to its interactions with sodium ion channels.
4. Pethidine has apparent but no true efficacy as an "antispasmodics"
5. Pethidine also has stimulant effects mediated by its inhibition of the dopamine transporter (DAT) and norepinephrine transporter (NAT).
6. Pathidine differs from morphine.
    - It is more lipid-soluble and thus faster onset of action.
    - Its clinical effect is shorter ,i.e. 120-150 minutes.
    - It is less effective than morphine at easing severe pain, or pain by movement. Pethidine may be more addictive for its exceptionally rapid in action and activity as a monoamine transporter inhibitor (cocaine-like).

Adverse reactions

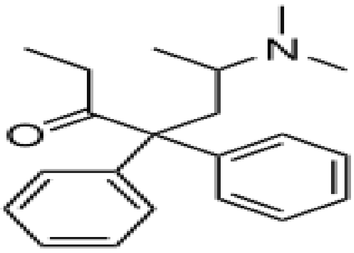
- Addictive- tolerance, physical and psychological dependences.
- Shows unique side effects like - serotonin syndrome, seizures, delirium, dysphoria, tremor due to the action of its metabolite, norpethidine.

Uses

1. Pethidine is used for the treatment of moderate to severe pain.
2. Pethidine was the opioid of choice for acute pain and for chronic severe pain

2.1.4.3. Methadone

Methadone is a synthetic opioid, used medically as an anti-addictive analgesic. It was developed in Germany in 1937. Although chemically methadone is an acyclic structure, it acts on the opioid receptors and produces many of the same effects. It is administered as methadone hydrochloride tablet or injection (5 meg to 10 mg).



Methadone

Mode of action

1. Methadone is a full d-opioid agonist.
2. Methadone also binds to the glutamatergic NMDA (N-methyl-D-aspartate) receptor, and thus acts as a receptor antagonist against glutamate, the primary excitatory neurotransmitter in the CNS.
3. Methadone acting as an NMDA antagonist may be one mechanism for eliminating addiction/tolerance or withdrawal possibly by disrupting memory.
4. Methadone binding with glutamatergic NMDA receptor as a possible mechanism for its distinguished efficacy on neuropathic pain treatment.

Adverse effects

- Hypoventilation.
- Decreased bowel motility – constipation.
- miotic pupils, hypotension and nausea.
- When combined with other drugs, it may cause death.

Uses

1. Methadone is used in managing chronic pain.
2. Methadone is the best analgesic to treat pain of long duration and very low cost.
3. It reduces and/or eliminates the use of heroin, reduces the death rates.
4. It allows patients to improve their health and social productivity.
5. It suppress the abstinence syndrome, and block the euphoric effects.

2.2. Antipyretic analgesics

2.2.1. These non-norcotic drugs have principally analgesic, antipyretic, and anti-inflammatory actions. They do not bind to opioid receptors and are not classified under the controlled substances act.

2.2.2. Antipyretics analgesics mode of action

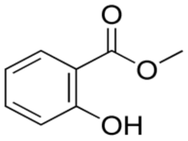
1. Antipyretics are drugs that reduce body temperature in situations such as fever.
2. Antipyretics cause the hypothalamus to override an interleukin-induced increase in temperature. The body then works to lower the temperature and reduce fever.
3. They are also used as-pain relievers, antipyretic and anti-inflammatory activity also.
4. The replacement of -H for -OH by acyl radicals in salicylic acid yields less soluble.

2.2.3. Salicylic acids and its derivatives - Salicylates

1. They are colorless/pale colored precursor that are heat-sensitive recording material.
2. These are metal salt or an aliphatic amide compound of salicylic acid and are excellent in thermal response and preservation stability.
3. They produce antipyretic analgesic and anti-inflammatory effects.
4. These are qualitatively alike but quantitatively different in action.

2.2.3.1. Methyl salicylate

Methyl salicylate (betula oil, oil of wintergreen, methyl-2-hydroxybenzoate) is a natural product of many plants. (Eastern Teaberry-*Gaultheria procumbens)*. Synthetically it is produced by esterifying salicylic acid with methanol in the presence of sulphuric acid. It is a colourless/ pale yellow liquid with warm aromatic odour and, sweet taste.



Methyl salicylate - Molecular formula: $C_6H_4(HO)COOCH_3$

Mechanism of Action

Methyl salicylate is used with high potent to enter through the skin for external use for it is free from the basic characters of salicylic salts like the gastric irritation and unpleasant taste.

Uses

It is applied in ointments for the relief of pain for it is absorbed through the skin. It is also used as a flavour in many pharmaceutical preparations and as perfumes in insecticides.

Adverse effects

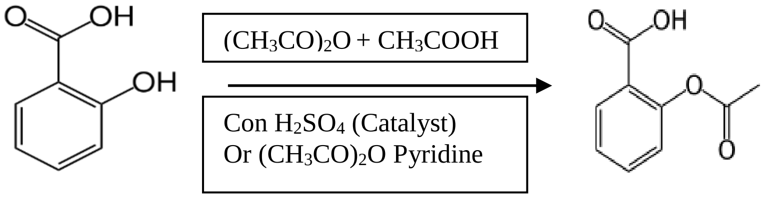
In pure form, it is toxic, when taken internally(lethal dose is 101mg/kg body weight)

It has proven fatal to small children and will not affect the normal body temperature.

2.2.3.2. Aspirin

Aspirin, or acetylsalicylic acid is prepared by the acetylation of salicylic acid with acetyl chloride or acetic anhydride. The latter method is less expensive and generally employed.

It is a colourless crystal or white crystalline powder/granules. It is odourless with a slight acid taste. It is slightly soluble in water. Aspirin was first-discovered member of (NSAID) class of drugs called non-steroidal anti-inflammatory drugs.



salicylic acid acetylsalicylic acid/Aspirin

Mechanism of Action

1. Aspirin like other NSAIDs inhibit cyclooxygenase, leading to a decrease in prostaglandin production; this reduces pain and also inflammation.

2. Aspirin in high doses (essentially for acute heart attack) inhibits the synthesis of prothrombin and therefore produce a second and different anticoagulant effect.
3. Aspirin shows some mechanism of action involving non-selective inhibition of enzyme cyclooxygenase.

Adverse effects

1. Gastrointestinal distress-including ulcers and stomach bleeding—and tinnitus, especially in higher doses.
2. Increased bleeding in menstruating women, due to its anticoagulant properties.
3. For children under 12 years of age, aspirin is no longer used to control flu-like or chickenpox due to the risk of Reye's syndrome.

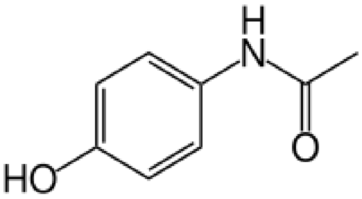
Uses

1. An analgesic (to relieve minor aches and pains) and antipyretic (to reduce fever);
2. An anti-inflammatory (for inflammations in joints).
3. An antiplatelet (anti-clotting) effect; (long-term, low doses to prevent heart attacks)
4. Used in the treatment of rheumatic fever/arthritis.
5. In lower doses, it decreases transient ischemic attacks and unstable angina.

2.2.4. p-aminophenol derivatives

2.2.4.1. Paracetamol

Paracetamol or acetaminophen is the active metabolite of phenacetin. It is a non-carcinogenic one showing analgesic, antipyretic properties, but not anti-inflammatory. It is a white crystalline solid with bitter taste. It is slightly soluble in water.



Paracetamol

Mechanism of Action

1. Paracetamol reduces the oxidized form of COX enzyme. Since reduced COX family of enzymes are not capable of metabolising arachidonic acid to

prostaglandin H2 and then to other pro-inflammatory compounds, it leads to analgesic state.

2. Paracetamol is metabolized to AM404 to act as follows:

(a) it inhibits the uptake of the endogenous cannabinoid/ vanilloid anandamide by neurons leading to non-activation state of the main pain receptor (nociceptor) of the body.

(b) AM404 inhibits sodium channels, like anesthetics. This actions reduces the pain.

Adverse effects

1. High dose-usage (<2000 mg) increase the risk of upper gastrointestinal problems.
2. Fasting is risky for it reduces hepatic glutathione and it may damage the liver.
3. Excessive alcohol can lead to paracetamol toxicity.

Uses

1. Paracetamol is well tolerated and is used for the relief of fever, headaches.
2. It is also used to control other minor aches and pains.
3. It is used with non-steroidal anti-inflammatory drugs/opioid to control severe pain.
4. It has minimum side-effects.
5. It is a major ingredient in many cold and flu drugs.
6. It is considered safe for human at recommended doses

2.3. ANTISEPTICS AND DISINFECTANTS

2.3.1. An **antiseptic** is a substance which inhibits the growth and development of microbes.

Antiseptics may be described as:

1. antimicrobial substances that are applied to living tissue to reduce the infection, sepsis, or putrefaction.
2. some are true germicides (bacteriocidal) and others are bacteriostatic (prevent or inhibit microbial growth).

Disinfectants are agents used on inanimate objects to kill bactyeria but not the spores.

Disinfectants may be described as:

- antimicrobial agents applied to non-living objects to destroy microorganisms;

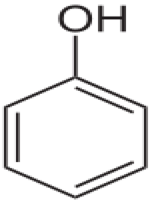
- endospores are resistant to disinfectants for it depend on their mode of application.

2.3.2. Differences between Antiseptics and Disinfectants.

Antiseptics	**Disinfectants**
1. Antiseptics are used on living tissues like wounds, sepsis or putrefaction.	1. Disinfectants are domestic and hospiral sanitary materials for hygene.
2. They are used to kill microbes in local infections and to prepare skin for surgical procedures.	2. They are used to disinfect water, utensils and to sterilize vaccines, medical products and tissue grafting.

2.3.3. Phenolic compounds

- Phenol (carbolic acid) compounds.
- It is a colourless, or faintly pink deliquescent crystalline materials soluble in water.
- It has a characteristic odour.
- Phenol is germicidal in strong solution.
- It is germ inhibitory one in weaker solutions.



Phenol

Uses

- Phenol is used as germicide in 80% solutions; for dressing wounds in 2% solutions.
- Used in mouthwashes and throat lozenges, both as a painkiller and antiseptic.
- Used as a "scrub" in pre-operative hand cleansing; also as an antiseptic babypowder.

Dyes

In olden days natural dyes have been used in all walks of life. Presently stable synthetic dyes are used. Some are used as antiseptics, chemotherapeutics, colouring agent etc.,.

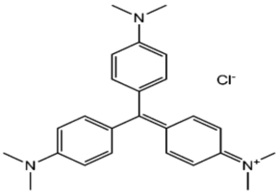
2.3.3.1. Crystal violet or Gentian violet or Methyl violet 10 B

Methyl violets are mixtures of tetramethyl, pentamethyl and hexamethyl pararosanilins. The more methylated, it makes the compound (the more methyl groups) the deeper blue. crystal violet is soluble in water, ethanol, diethylene glycol, and dipropylene glycol.

- Hexamethyl (methyl violet 10B)-**crystal violet**.

Mechanism of action

It can enter through the bacterial cell wall and thus it destroys cells. Its methyl group is a high level inhibitor and a poison. It is used as a moderate-strength external disinfectant.



*

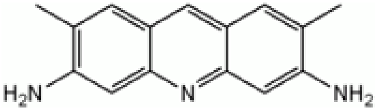
methyl violet.*
gentian violet.
crystal violet.

Uses

It is an antiseptic and is an effective agent against Gram positive bacteria. It is the active ingredient in Gram's stain to identify Gram positive bacteria. In aquous solution topically used for the treatment of burns, boils, skin infections and ulcers.

2.3.3.2. Acridine yellow

Acridine yellow, also known as acridine yellow G, 3,6-diamino-2,7-dimethylacridine, is a yellow dye with strong bluish-violet fluorescence. It is a derivate of acridine.



Acridine

Mechanism of action

Amino group of acridine is active in destroying cellular structures of most of the parasites.

The cations of acridine derivative injure bacteria by competing with H^+ required by bacteria.

This is highly active in the presence of pus and body fluids due to the diamine active groups.

Uses

- In histology, it is used as a fluorescent stain to show the cytoplasmic pH.

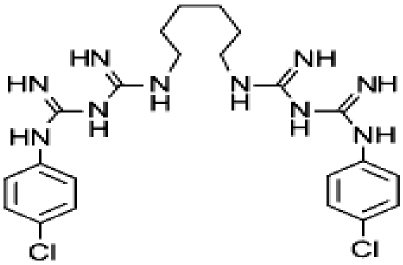
- It is also used as a topical antiseptic (as hydrochloride salt for application)
- Active membrane and cytocidal on many bacteria and parasites (Tryupanosomes).
- They are used as urinary antiseptics only when urine is basic.

2.3.4. Chloro-compound

Chloro-compounds or Chlorophores consist of N-chloramine derivatives that release hypochlorousacid on hydrolysis. These are used to treat wounds instead of hypochlorites for it is less irritating, longer acting and possible inactivation.

2.3.4.1. Chlorhexidine

Chlorhexidine is a chemical antiseptic. It is bactericidal and bacteriostatic. Two parachlorophenyl substituted biguanidine units are linked through a hexamethylene chain forms chlorhexidine It is used as acetate and hydrochloride.



Chlorhexidine

Mechanism of action

The mechanism of action is membrane-disruption and not ATPase inactivation. It kills both gram-positive and gram-negative bacteria (bacteriostatic for some gram-negative microbes). Chlorhexidine is deactivated by anionic compounds especially anionic surfactants.

Uses

1. It is used as an ingredient in mouthwash to improve bad breath;
2. It kills dental plaque and oral bacteria etc.,.
3. It prevent gum diseases such as gingivitis.
4. It is also a component of household antiseptics.
5. It is used for general skin cleansing, as surgical scrub.
6. It is a pre-operative skin preparation.
7. It is often used as a rubbing agent prior to hypodermic or intravenous needles.

8. It can be used also as spermatocidal agent.
9. It is used in minute concentrations for contact lens.

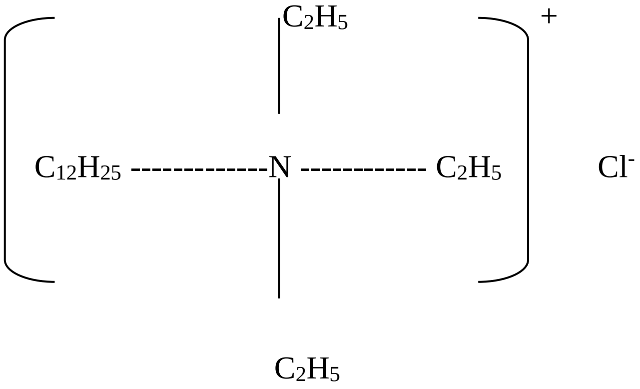
2.3.5 Surfactants

Surfactants, also known as tensides, are wetting agents that lower the surface tension of a liquid for easier spreading and lower the interfacial tension between two liquids. Cationic surfactant is one of the four groups identified by positively charged group in its head.

Cationic surfactants

They have emulsifying and detergent action and have bactericidal activity on gram-positive and gram-negative organisms. These compounds modify the characteristics of the interface between the liquids or a liquid and gas or a liquid and a solid or any general surface. These are effective in neutral solutions. Their bactericidal activity decreases in acidic medium.

Surfactants are identified by the presence of hydrophilic(affinity for water) and hydrophobic (lacking affinity for water or lipophilic group). Since the lipophilic groups are cations (C_2H_5 and $C_{12}H_{25}$), it is cationic surfactant. These are colourless, odourless, non-irritating and non-toxic in nature. These are water soluble and non-corrosive on metals and rubbers. They readily combine with proteins and show reduced activity in the serum, pus and other orgnic matters. These are also incompatible with anionic surfactants like soap.



$$\left[C_{12}H_{25}-\overset{C_2H_5}{\underset{C_2H_5}{N}}-C_2H_5 \right]^+ Cl^-$$

Mode of action

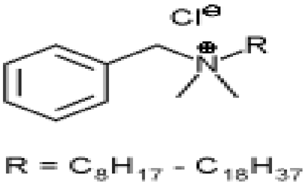
These surfactants dissociate into a large and complex cation and smaller inactive anion. The cation usually contains a pentavanent nitrogen and as a quarternary ammonium, pyridinium or poperidinium group or as aliphatic quarternary ammonium salt. The hydrocarbon chain usually contains 8 or 16 carbon atoms. These are antimicrobial and act by lowering the surface tension. As a result the cell membrane of the microbe is damaged and they die.

Uses

1. These are used as skin disinfectant.
2. These are also used as an disinfectant for clothes.
3. These are largely used in creams, ointment, surface/talc powders.
4. These are also used as antiseptics.

2.3.5.1. Benzalkonium chloride

Benzalkonium chloride, (alkyl dimethyl benzyl ammonium chloride), is pale yellow in colour; readily soluble in alcohol/ acetone; dissolves slowly in water. It is a detergent and emulsifyer; foams profusely, tastes bitter and smells almond-like.



Mechanism of action

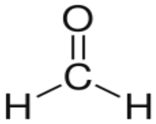
The biocidal activity is associated with the C12-C14 alkyl derivatives and their action in the disruption of intermolecular interactions. i.e.cause dissociation of cellular membrane bilayer and other biomolecular complexes; damage cellular permeability controls; deactivation of enzymes, controlling plethora of respiratory and metabolic cellular activities critical intermolecular interactions and tertiary structures of hacterial cytoplasmic matrix.

Uses

- It is used in pre-operative disinfection of unbroken skin.
- It is used in high dilution as an antiseptic for wounds, burns and in obsterics.
- It is used for disinfecting surgical instruments and baby diapers to prevent rashes.
- Its lozenges are used for the treatment of pharyngeal and also for vaginal infection.

2.3.5.2. Formaldehyde

Formaldehyde is the simplest aldehyde. It was synthesized by Aleksandr Butlerov and identified by August Wilhelm von Hofmann. It is a colourless liquid with characteristic odour and burning tase. It forms formalin with methanol; an aqueous fumigant with water.



Mechanism of action

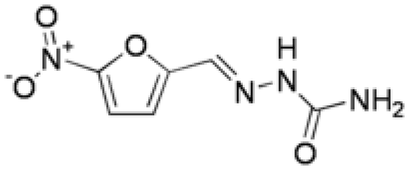
As methanol it is metabolised into toxic formaldehyde by the Cytochrome P450 enzyme. Thus it precipitates the cellular proteins and lead to the microcidal activity.

Uses.

1. Aqueous formaldehyde is used as a disinfectant (kills bacteria, fungi,all spores).
2. It is also used as a preservative in vaccinations.
3. Formaldehyde solutions are applied topically to dry the skin, to treat the warts.
4. Many aquarists use formaldehyde as a treatment for the parasite ichthyophthirius.

2.3.5.3. Nitrofurazone

Nitrofurazone, 2-((5-nitro-2-furanyl)methylene) hydrazinecarboxamide, chemical formula C6H6N4O4, is a pale yellow crystalline compound. It is soluble in water.



Nitrofurazone or **nitrofural** or **furacilin**

Mechanism of action

The antibacterial action is due to its inhibition of bacterial respiratory enzymes. It also blocks the energy transfer by the organism during cell division.

Uses

It is an effective antiseptic against both gram-positive and gram-negative bacteria.

It is used as an antiseptic for infections due to burns, ulcers, wounds and other skin diseases.

2.4. Anaesthetics

2.4.1. Anesthesia or anaesthesia (an- “without” + aisthesis “sensation”) has traditionally meant the condition of having the feeling of pain and other sensations blocked. This allows patients to undergo surgery and other procedures without the distress and pain they would otherwise experience. The word was coined by Oliver Wendell Holmes, Sr. in 1846.

An ideal anaesthetic agent should have the following characteristics. They should be :

- inert, potent, non-flammable and non-irritating to the mucous membrane.
- able to give enough relaxation time for the surgery to be performed.
- free from toxic effect on heart, brain, liver, kidney etc.,.
- free from the effect of reducing the blood pressure.
- Having analgesic action and muscle relaxation.
- free from the induction for vomiting or nausea.
- not antagonistic to other drugs.
- stable to light and heat.
- economical.

2.4.2. There are two types of anaesthetics:

1. General, which make the patient unconscious.
2. Local, which numb the part of the body that would otherwise feel pain.

2.4.2.1. General anesthesia in its most general form can include:

- Analgesia: blocking the conscious sensation of pain;
- Hypnosis: produces unconsciousness without analgesia;
- Amnesia: preventing memory formation;
- Relaxation: preventing unwanted movement or muscle tone.

General anesthesia produce unconciousness all over the body, by depressing the brain. General anesthesia refers to "Drug-induced loss of consciousness during which patients are not arousable, even by painful stimulation." Patients undergoing general anesthesia can neither maintain their own airway nor breathe on their own. They are usually administered with inhalational agents, but can be achieved with intravenous agents, such as propofol.

2.4.2.2. Local/regional anesthesia abolishes the sensation of pain in specified/local area

- Loss of pain sensation,
- varying degrees of muscle relaxation,
- Limited to certain regions of the body.

Local/regional anesthesia refer to states achieved by anesthetics working outside the brain.

Regional anesthesia may be administed to peripheral nerve bundles, such as the brachial plexus in the neck. Examples include the interscalene block for shoulder surgery, axillary block for wrist surgery, and femoral nerve block for leg surgery. Local anesthesia is similar to regional anesthesia, but exerts its effect on a smaller area of the body.

2.4.3. Volatile Anaesthetics are a class of general anaesthetic drugs. They are liquids at room temperature, but evaporating easily for administration by inhalation (volatile and gas anesthetics do not differ in mechanism of action). These are hydrophobic (i.e., as liquids, not freely miscible with water, and as gases, dissolve in oils).

Mechanism Of Action

"It looks like inhaled anesthetics act on multiple molecular targets".

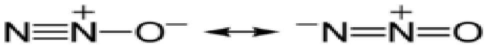
The possibility of anesthesia by the inert gas suggests that the mechanism of action is:

1. an effect based on physical properties of binding to a receptor in a weak interaction-as:
    (i) Boyle's law;
    (ii) Dalton's law of partial pressure; and
    (iii) Graham's law of diffusion, etc.,.
2. often governed by four stages that may be different for each gas – as:
    (i) Stage of analgesia (leading to loss of consciousness).
    (ii) Stage of delirium (leading to the beginning of surgical anaesthesia).
    (iii) Stage of surgical anaesthesia (leading to deep breathing when reflex is lost).
    (iv) Stage of respiratory paralysis (leading to depression of medullary centres).

The process may be open, semi-open, closed (soda-lime to absorb CO2) or semi-closed.

2.4.3.1. Nitrous oxide

Nitrous oxide (laughing gas - N_2O) is a colorless, non-flammable gas at room temperature. It has a pleasant, slightly sweet odour taste. It is non-flammable and also non irritating.



$$N\equiv\overset{+}{N}-O^{-} \longleftrightarrow {}^{-}N=\overset{+}{N}=O$$

Different forms of N_2O

Uses

1. Nitrous oxide is used in surgery and dentistry for its anesthetic and analgesic effects.
2. It is a dissociative drug that can cause analgesia, depersonalization, euphoria, derealization, dizziness, sound distortion and slight hallucinations.
3. Its prolonged analgesic action helped in obstetrical, wound/burn cleaning and dressing.
4. It also provides rapid induction and rapid recovery.
5. Presently it is used as a carrier gas in a 2:1 ratio with oxygen before powerful anesthetia.

Disadvantages

1. Due to the euphoric effects of inhaling it, it is not used as a medical anaestheic drug.
2. When nitrous oxide is used, pre and post anaesthetic medication like Vitamin B12 check, continuous fresh-air ventilation and nitrous-scavenging system are essential.
3. It may also increase cardiac irregularities.

2.4.3.2. Ether

Anaesthetic either is 96-98 percent Diethyl either. It (ethoxyethane) is a clear, colorless, flammable liquid with a low boiling point(35°C) and a pungent smell. Ether is sparingly soluble in water and is soluble in organic solvents. The American doctor Crawford Williamson Long, M.D., was the first surgeon to use it as a general anesthetic.

$C_2H_5 \text{——} O \text{——} C_2H_5$ It has the formula $CH_3\text{-}CH_2\text{-}O\text{-}CH_2\text{-}CH_3$.

Uses

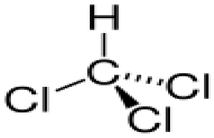
1. Diethyl ether induces surgical anaesthesia without any pre-anaesthetic medication.
2. It is generally safe. It produces muscular relaxation and has analgesic action also.
3. It does not modify blood pressure.
4. It is devoid of liver and kidney toxicity.
5. It is economical and is quite stable, if stored properly.

Disadvantages.

1. It has a slow induction and slow recovery.
2. Alcoholics, being tolerant to ether, induction may be difficult.
3. Ether, basically an irritant, may induce cough during induction.
4. During recovery it may develop postanesthetic nausea and vomiting.

2.4.3.3. Chloroform

Chloroform (trichloromethane or methyl trichloride) is a colourless volatile liquid of characteristic odour and sweet burning taste. It is non-inflammable and is miscible with water. It has to be kept tightly closed without light to avoid any oxidation.



It has the formula $CHCl_3$

Uses

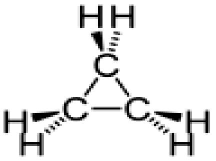
1. It is used as an inhalation anesthetic for it depresses the central nervous system, causing dizziness, fatigue and unconsciousness, allowing simple surgery to be done.
2. It is non-flammable and highly potent.

Disadvantages.

1. During recovery it may develop postanesthetic nausea and vomiting.
2. It causes liver and cardiac toxicity and metabolised to phosgene in kidneys.
3. Storage of cholorform is difficult even with stabilizer.

2.4.3.4. Cyclopropane

Cyclopropane is a cycloalkane molecule. It is an anaesthetic. It is a colourless inflammable gas with a sweet odour and taste. It is soluble in alcohol, ether and chloroform.



Its molecular formula is C_3H_6.

Uses

1. Cyclopropane is a potent, non-irritant to respiratory passages, anaesthetic agent.

2. Both induction and recovery are fast and smooth without nausea and vomitting
3. Muscular relaxation is very good and extended with the dosage.
4. Blood pressure and cardiac activity are sustained even on prolonged administration.

Disadvantages.

1. Because of smooth induction, the overdose danger should be watched.
2. A slight change from the slow and smooth administration may cause breath-holding.
3. Pre-medication before the administration of cyclopropane is essential.

2.4.4. Non-volatile - Intravenous anesthetics

Non-volatile general anaesthetics, often calleld the intravenous anesthetics, are expected to reduce brain activity by potentiating inhibitory GABA(A) receptor channels. They cause reduced excitability of sensorimotor neurons in sections of the spinal cord by suppressing plateau potentials mediated by L-type calcium channels. These are administered via the intravenous route to reach therapeutic level quickly. They are also reliable and convenient.

2.4.4.1.These are classified into opioids, non-opioids and muscle relaxants.

Opioids

These are commonly known as narcotics. They are used mainly for analgesia (pain relief). In higher doses they decrease anxiety and cause unconsciousness. E.g.: morphine, meperidine, fentanyl, sufentanil(differ in potency and duration of action).

Non-opioids

Non-opioids are useful for the induction of anesthesia; They are barbiturates and others. Barbiturate is commonly used: i.very short acting- Thiopental; ii.short acting- methohexitone Others are given for sedation, anxiety, sleep, etc.:diazepam, lorazepam, and midazolam.

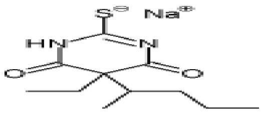
Muscle relaxants

Muscle relaxants don't provide pain relief or unconsciousness but are important for the total muscle relaxation to achieve best operating condition and safety. They are:

(i) depolarizing muscle relaxants – Succinycholine; (ii) non-depolarizing muscle relaxants - short-acting: mivacurium; intermediate-acting: vecuronium; and long-acting: pancuronuim.

2.4.4.2. Sodium thiopental

Sodium thiopental (thiopental sodium) is a rapid-onset intravenous ultra-short-acting drug. It is a depressant and is used for interrogations - to weaken the resolve of the subject. It is a yellowish white hygroscopic powder, a unique odour and bitter taste. It is soluble in water.



The chemical formula is $C_{11}H_{17}N_2NaO_2S$

Uses

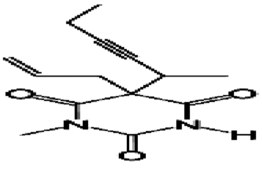
1. Thiopental, ultra-short-acting barbiturate, is non-explosive and easy to administer.
2. Its induction is rapid, and so it is used in induction phase of general anesthesia..
3. The recovery is fast and the tendency of nausea, vomiting and excitement are less.
4. Psychiatrists use it to desensitize patients with phobias and to recall memories.

Disadvantages.

1. Thiopental may cause cardiovascular and respiratory depression resulting in apnea, hypotension and airway obstruction and so well trained medical personnel is necessary.
2. It may lead to side effects like headache, delirium, prolonged somnolence and nausea.
3. It is a poor analgesic and leads for less muscular relaxation.

2.4.4.3. Methohexitone

Methohexital is a methylated derivative of oxybarbiturate derivative. It is provided as a sodium salt. It is a white crystalline powder and sparingly soluble in water.



Its molecular formula is $C_{14}H_{18}N_2O_3$

Uses

1. It is mostly used in hospital or ambulatory care settings, under supervision.
2. It is a short-acting, rapid onset anesthesia and is is used in induction phase.

3. It is non-explosive and easy to administer and the recovery is fast with less nausea.
4. Psychiatrists use it to desensitize patients with phobias and to recall memories.

Disadvantages.

1. Like thiopental, it may cause cardiovascular and respiratory depression etc., problems.
2. It may lead to side effects like headache, delirium, prolonged somnolence and nausea.
3. It is a poor analgesic and leads for less muscular relaxation.

2.4.5. Local anesthesia

Local anesthesia is any technique to render part of the body insensitive to pain without affecting consciousness. It allows patients to undergo surgical and dental procedures with reduced pain and distress. It is expected to have the following characteristics:

(i) Non-irritant; (ii) painless; (iii) very low toxicity; (iv) easy to sterilize; (v) fast acting; (vi) stable and (vii) should not damage the nerves.

2.4.5.1. It may be technically classified as:

I. Area of activity

1. Local anesthesia works on a small part of the body like tooth or an area of skin.
2. Regional anesthesia anesthetize a larger part of the body such as a leg or arm.

II. Origin.

1. Natural – derived from biological sources. E.g. cocaine.
2. Synthetic nitrogenous compounds – with nitrogen in amine form. E.g. Benzocaine.
3. Synthetic non-nitrogenous compounds – without nitrogen. E.g. Benzyl alcohol.
4. Miscellaneous – derivatives of oil and other compounds. E.g. Clove oil.

III. Method of Usage.

1. Surface anaesthesia – used as ointment to relieve pain due to ulcers, burns etc.,.
2. Infiltration anaesthesia – used for direct exposure and administered subcutaneously.

3. Spinal anaesthesia – used for special medication and administered at dual membrane.

IV. Organic derivations.

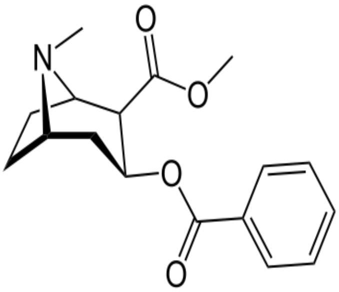
1. esters – (C_6H_5 –COO- R).   2.Amides – (C_6H_5 –CONH- R).

2.4.5.2. Mechanism of action

To achieve conduction anaesthesia a local anesthetic is injected or applied to a body surface. The local anesthetic then diffuses into nerves where it inhibits the propagation of signals for pain, muscle contraction, blood circulation and other body functions. Higher doses or inhibit all qualities of sensation (pain, touch, temperature etc.) as well as muscle control. Lower doses may selectively inhibit pain sensation with minimal effect on muscle power. In many situations, such as cesarean section, it is safer than general anesthesia. It is also used for relief of non-surgical pain and to enable diagnosis of the cause of some chronic pain.

2.4.5.3. Cocaine

Cocaine (benzoylmethyl ecgonine) is a crystalline tropane alkaloid. It is obtained from the leaves of the coca plant (*Erythroxylon coca*). It is a white crystalline powder and sparingly soluble in water. Its hydrochloride is soluble in water and is hygroscopic in nature. Cocaine directly works on the central nervous system and blocks the dopamine transporter protein, leading to dopamine accumulation. This results in an enhanced post-synaptic effect of dopaminergic signaling. Such an enhanced signal as an addiction becomes normal level.



Its formula is $C_{17}H_{21}NO_4$

Uses

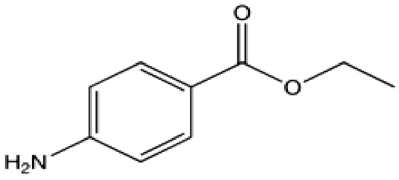
1. It is both a stimulant of the central nervous system and an appetite suppressant.
2. Cocaine is used in medicine as a topical anesthetic in eye, nose and throat surgery.
3. Cocaine is a local anaesthetic also.

Disadvanatages

1. It is a dopamine reuptake inhibitor and thus it is an addictive.
2. It dialates pupil of the eyes and raises the blood pressure.
3. It may be both poisonous and allergic.
4. It produces euphoria and fatigue.

2.4.5.4. Benzocaine

Benzocaine is an ester of PABA (para-aminobenzoic acid). It is a white crystalline powder. It has to be stored in tight light resistant container. It is a a low toxic weak base. It is not soluble in water. Benzocaine, the ester of PABA, work as a chemical barrier, stopping the sodium ion from entering the nerve ending. Eventually the pain expressing electrical potential gets inhibited, the signal is not realised by the central nervous system as pain.



Its molecular formula is $C_9H_{11}NO_2$

Uses

1. Benzocaine is a local anesthetic commonly used as a topical pain reliever.
2. It is the active ingredient in many anesthetic ointments and for oral ulcers.

Disadvantages

1. It is an addictive and is rarely used as a topical anesthetic.
2. It may be both poisonous and allergic.

2.5. Antianaemic drugs

Anemia or **anaemia** from the Greek meaning "without blood", is a deficiency of red blood cells (RBCs) and/or hemoglobin. This results in a reduced ability of blood to transfer oxygen to the tissues, causing tissue hypoxia. The three main classes of anemia include excessive blood loss (acute hemorrhage or chronical low-volume loss), excessive blood cell destruction (hemolysis) or deficient red blood cell production (ineffective hematopoiesis).

When deficiency has been diagnosed, it can be treated with

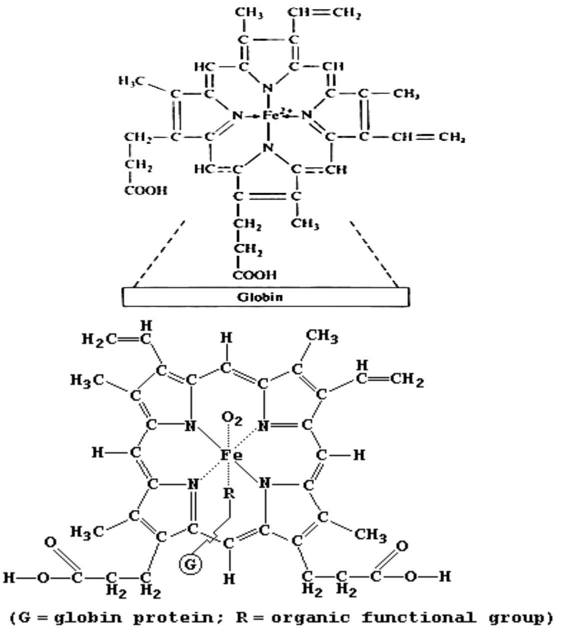
1. iron supplements (ferrous sulfate, ferrous gluconate, or amino acid chelate tablets).
2. vitamin supplements given orally (folic acid) or
3. subcutaneously vitamin β-12 will replace specific deficiencies.

2.5.1. Iron deficiency

Total body iron averages approximately 3.8 g in men and 2.3 g in women. The main iron regulatory mechanism is in the gastrointestinal tract. When the loss is not compensated by adequate intake, iron deficiency develops leading to iron deficiency anemia. The daily requirement of iron is 8-18mg for children, 15-20mg for women and 10-15mg for men. This is common among children and pre-menopausal women. Iron from plant sources is less easily absorbed than the heme-bound iron of animal sources. Legumes and dark-green leafy vegetables and oriental greens are especially good sources of iron for vegetarians.

2.5.1.1. Mode of action of Iron

In haemoglobin iron remains in ferrous form and when it combines with oxygen it is not converted into ferric form (not oxidised and so it is oxyhaemoglobin). The combination of haem with globin helps this combination of oxygen loosely with reversible potentiality.



(G = globin protein; R = organic functional group)

Deoxygenated Haemoglobin Oxygenated Haemoglobin

2.5.1.2.Iron as a drug

Moderate iron deficiency anemia is treated by iron supplementation with ferrous sulfate or ferrous gluconate. Vitamin C may aid in the body's ability to absorb iron. In chronic ones, drugs like Iron dextran or Iron sorbitol ctric acid complex are used parenterally (in injection)

However ‘Pyridoxime HCL’ is used to accelerate iron utilization in Haemoglobin formation.

2.5.2. Vitamin B_{12} deficiency

Megaloblastic anaemia by Vitamin B_{12} deficiency is expressed by abnormally large RBC with normal haemoglobin content. This results in a reduced ability of blood to transfer oxygen and tissue methylmalonic acidity.

2.5.2.1. Mode of action - Vitamin B_{12}.

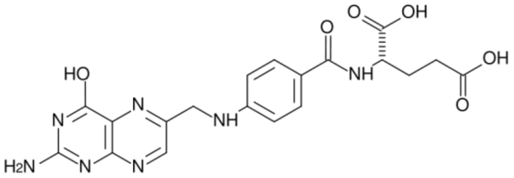
Cyanocobalamin, Vitamin B_{12}, is important for the normal functioning of the brain and nervous system and for the formation of blood. It is involved in the metabolism of every cell of the body, in DNA synthesis and regulation, fatty acid synthesis and energy production.

2.5.3. Folic acid deficiency

Increased homocysteine can also be diagnostic of a folic acid, Vitamin B_9 deficiency. Eventually it affects DNA synthesis and effective production of blood cells in bone marrow.

2.5.3.1. Mode of action of Folic acid

It is an yellow orange tasteless, odourless, non toxic crystalline powder. Folic acid (folate - anion form $C_{19}H_{19}N_7O_6$) is a water-soluble. It is essential in converting homocysteine to methionine and to avoid anemia. It naturally occurs in food and it can also be supplimented.



Pteroyl-L-glutamic acid or Folic acid

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Unit - III

3.1.Drugs affecting CNS

Definition

The central nervous system directs the functions of all tissues of the body. The CNS processes all the incoming information and discards 99% as unimportant. After sensory information has been evaluated, selected areas of the central nervous system initiate nerve impulses to organs or tissue to make an appropriate response.

Chemical influences are capable of producing a myriad of effects on the activity and function of the central nervous system. The known neurotransmitters are:

1. acetylcholine which is involved with memory and learning;
2. norepinephrine which is involved with mania-depression and emotions; and
3. serotonin which is involved with biological rhythms, sleep, emotion, and pain.

Many drugs exert their action through excitation/inhibition of the central nervous system. Psychic stimulants include various amphetamines etc.,.

3.1.1. These may be classified as follows:

1. Tranquillizers: Drugs which imporove the mood and behaviour of patients.
2. Sedatives: Drugs that depress the CNS and reduce restlessness without producing sleep.
3. Hypnotics: Drugs that depress the CNS and produce sleep to reduce emotional tensions.
4. Psychodelic drugs: Drugs that induce altered perception and thought (hallucinogen).

3.1.2. Tranquillizer may be described as:

It is used to reduce anxiety, fear, tension, agitation and related states of mental disturbance.

It gives strong sedation without sleep and produce a state of indifference and disinterest.

It also reduces excitation, aggressiveness that is not controlled by sedatives and hypnotics.

3.1.2.1. Mechanism of action:

Tranquilizer drug calms the central nervous system and decreasing emotional agitation without impairing alertness. Tranquilizing drugs do not act on the brain's cortical areas but act on its lower portions, e.g., the hypothalamus . They have been found helpful in the treatment of tension and mental illness.

Tranquilizers may be classified as -

(i) Major tranquilizers – Antipsychotics or Neurolwptics.

E.g. Reserpine; Phenothiazines

(ii) Minor tranquilizers – Antianxiety agents.

E.g. Meprobamate; Benzodiazapines.

(iii) Anti depressants – Improves the mood.

E.g. lithium carbonate; Caffeine.

(iv) Psychotogenic drugs – Induce behavioral abnormalities.

E.g. LSD and Mescaline.

3.1.3. Sedatives and hypnotics may be described as:

Sedation is characterised by decreased anxiety, motor activity and cognitive activity while hypnosis is characterised by drowsiness and an increased tendency to sleep. They may be called tranquilizers, depressants, anxiolytics, soporifics or hypnotics. They induce slow breathe, calmness, relaxation, reduction of anxiety and sleepiness. They effect staggering gait, slurred speech, poor judgment with uncertain reflexes. These depress the CNS.

3.1.3.1. Mechanism of action

These drugs facilitate γ-amino butyric acid (GABA) mediated inhibition of neuronal activity in the CNS. They bind to the specific receptors (Benzodiazipine receptor I & II) that is part of, but distinct from, the pentameric GABAγ -receptor –chloride channel complex, having four subunits (αβγδ) and their multiple iso form in different proportions. They allosterically increases GABA affinity and increase GABA stimulated chloride channel opening. They also inhibit depolarisation by exitation. However they do not act in the absence of GABA.

Types of sedative-hypnotics

1. ***Antidepressants*** - psychiatric medication or other substance (nutrients like phenylalanine, tyrosine etc.,) used for alleviating depression or dysthymia ('milder' depression)**Trazodone.**
2. ***Barbiturates*** - are central nervous system depressants and they produce mild sedation to anesthesia. Some are also used as anticonvulsants. **Amobarbitol.**
3. B**enzodiazepines** - are psychoactive drugs with varying hypnotic, sedative, anxiolytic, anticonvulsant, amnesic properties, mediated by

slowing down the CNS. They are useful in treating anxiety, insomnia, seizures, muscle spasms, and alcohol withdrawal. **Diazepam.**

4. **Typical antipsychotics** (major tranquilizers) are antipsychotic drugs to treat psychosis (schizophrenia), acute mania, agitation, and other conditions. **Zuclopentixol**.
5. **Atypical antipsychotics** are used to treat psychiatric conditions. Some are used to treat schizophrenia, acute mania, psychotic agitation, bipolar maintenance. **Clozapine.**
6. **Antihistamine** inhibits the action of histamine; act on H_1 histamine receptor. **Niaprazine**

3.1.4. Psychedelic drugs

Psychoactive drugs primary act to alter the thought processes of the brain and perception of the mind. The psychedelics do not merely induce familiar states of mind but rather shift the locus of experiences so that they are qualitatively different from those of ordinary consciousness. These are non-ordinary forms of consciousness such as trance, meditation, and dreams. "The psychedelic drugs can develop unused potentials of the human mind."

3.1.4.1. Mechanism of action

It produces hallucinations or altered states of consciousness with sensory experiences of auditory, visual, tactile, olfactory, or gustatory fields or in any combination. The psychedelic effects may be peripheral adrenergic action that are similar to LSD (lysergic acid diethylamide), mescaline and marijuana. It produces anticholineric action like sensory distortions. They often act on nor epinephrine (a neuro humour in CNS). They are capable of activating the body's endogenous cannabinoid system.

E.g.: Psychoactive drug pharmacological types.

1. Serotonergic psychedelics (serotonin 5-HT2A receptor agonists) :

At lower doses, these include sensory distortions, like warping of surfaces, different shape and color variations. Higher doses cause intense and fundamental distortions of sensory perception (synesthesia) or additional spatial or temporal dimensions.

(i) Tryptamine-based compounds like LSD and psilocybin.

2. Empathogens and/or entactogens (serotonin releasers) :

Phenethylamines the effects of which are characterized by feelings of openness, euphoria, empathy, love, and heightened self-awareness, but not by visual hallucinations. They cause psychedelic effects without mental involvement and is a seritionin releaser.

(i) Phenethylamine-based compounds like mescaline (constituent of certain Cacti)

3.Cannabinoids (CB-1 cannabinoid receptor agonists)

The cannabinoid Tetrahydrocannabinol (THC) and related compounds are capable of activating the body's endogenous cannabinoid system. Some effects may include: general change in consciousness, mild euphoria, stress reduction, increased appreciation of humor, music and other art, joviality, metacognition and introspection, enhanced recollection of episodic memory, increased sensuality, , creative or philosophical thinking, disruption of linear memory, paranoia, and anxiety, potentiation of other psychedelics.

(i) Cannabinoid - constituent of cannabis (marijuana) Tetrahydrocannabinol.

3.2. Hypoglycemic agents

Diabetes mellitus is a disease arising from the inability of the body to metabolize glucose resulting in high blood glucose level (and ketoacidosis). It is divided into two classes :

Insulin-dependent (Type I) is a disease caused by the lack of insulin. Insulin must be taken.

Noninsulin-dependent (Type II) is a disease of insulin resistance by cells.

Treatments are: (1)increase secreted insulin; (2)increase sensitivity of target; (3)decrease glucose absorbtion. Anti-diabetic drugs treat diabetes mellitus by lowering glucose levels in the blood. With the exceptions of insulin, exenatide and pramlintide, all are administered orally and are thus also called oral **hypoglycemic agents** or oral **antihyperglycemic agents**.

3.2.1. Sulfonylureas

Sulfonylureas were the first widely used oral hypoglycemic medications. They are insulin secretagogues, triggering insulin release by direct action on the KATP channel of pancreatic beta cells. The "second-generation" drugs are common. But they may cause weight gain.

3.2.1.1. Mechanism of action

Sulfonylureas bind strongly to plasma proteins. Sulfonylureas are only useful in Type II diabetes, as they work by stimulating endogenous release of insulin. They work best with patients over 40 years. They can not be used with type I diabetes or at pregnancy.

Example

First-generation agents	Second-generation agents
tolbutamide (Orinase)	glipizide (Glucotrol)
acetohexamide (Dymelor)	glyburide (Diabeta, Micronase, Glynase)
tolazamide (Tolinase)	glimepiride (Amaryl)
chlorpropamide (Diabinese)	gliclazide (Diamicron)

3.2.2. Biguanides

Biguanides reduce hepatic glucose output and increase uptake of glucose by the periphery, including skeletal muscle. It must be used with caution in patients with impaired liver or kidney function. It is best for type 2 diabetes in children and teenagers. Amongst common biguanide, metformin is the only widely used oral drug; it does not cause weight gain.

3.2.2.1. Mechanism of action

In hyperinsulinemia, biguanides can lower fasting levels of insulin in plasma. It reduces gluconeogenesis in the liver eventually reduces glucose in the blood. It also tend to make the cells of the body absorb glucose from the blood and thus reduces glucose in the plasma.

Metformin (Glucophage) is the best choice for patients with heart problem. Metformin should be temporarily discontinued before radiographic for the risk of lactic acidosis. It is 500 mg to 1000 mg twice daily. It is also available with other oral diabetic drugs.

3.3.Cancer

Cancer is a defect in the cellular control mechanism resulting in uncontrolled cell division. The study of neoplastic growth or tumors is called ONCOLOGY. These tumers are:

Benign Tumours

These tumors are always localized and consist of well-differentiated cells. They do not establish contact with others. Generally these are harmless and can be removed by surgical operations. However, they may become quite harmful if at organs like brain and liver.

Malignant Tumours

These are true cancerous growths. These are invasive in nature. These are derived from single cell, thus monoclonal in character. The aberrant cell is usually embryonic type, undifferentiated, with large irregular nucleus and deficient in cytoplasm. These cancerous cells proliferate uncontrollably and have an infinite growth. It is characterized by metastasis.

Some of the common cancer diseases

Breast Cancer; Lymphoma; Colon and Rectal Cancer; Pancreatic Cancer; Prostate Cancer; Kidney (Renal Cell) Cancer; Skin Cancer (Nonmelanoma); Leukemia; Thyroid Cancer; Lung Cancer; Bladder Cancer; Melanoma Cancer; and Osteoma Cancer.

Causes

1. Triggering agents (carcinogens) such as diesel oil, Coal tar, cigarette smoke etc.,.
2. Pollutants like asbestos dust, exhaust fumes, and many industrial chemicals.
3. Many viruses like Retroviruses can also trigger the cancerous growth of cells,
4. X-rays and radioactivity.
5. Dietary factors like lack of fibre may predispose to bowel cancer.
6. A diet high in animal fats and low in vegetables increases the risk of breast cancer.
7. Psychological stress may increase the risk of cancer.

3.3.1. Treatment of Cancer

1. Surgery: In this method the cancerous cells/tissues are removed by surgery. However it has limitations for the left over cells or displaced migratory cells make secondary growth. 2. Radiation: In this method malignant tumours are exposed to radiation to get killed. 3. Chemotherapy: Chemotherapy drugs are sometimes feared because of their toxic effects and long period of treatment with expectations only to halt the growth and spread of cancer.

Classification and example of anticancer drug.

There are three goals associated with the use of most commonly-used anticancer agents.

1. Damage the DNA of the affected cancer cells.
2. Inhibit the synthesis of new DNA strands to stop the cell from tumor type replicatoin.
3. Stop mitosis or the actual splitting of cell into two cells to halt the progression of cancer.

Classification of drug categories based on their mechanism of action.

1) Methotrexate: no cell division.
2) 5-Fluorouracil: no production of DNA.

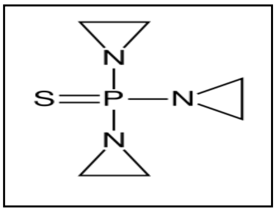
3) Hydroxyurea: no adenine.

4) Mercaptopurine: no adenine nucleotides.

5) Thioguanine: no guanine nucleotides.

6) Alkylating Agents: These involve reactions with guanine in DNA leading to addition of extra methyl or other alkyl groups and thus miscoding of DNA inhibits cell division.

3.3.2. Thiotepa

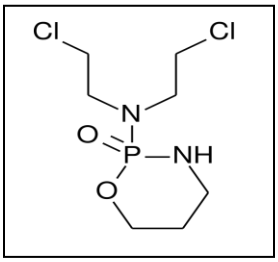


a. In this mechanism an alkylating agent attaches alkyl groups to DNA bases. This alteration fragments the DNA and the repair enzymes repeats the replacements again and again. E.g.: **Thiotepa**

Ethyleneimines and methylmelamines - *Thiotepa

N,N'N'-triethylenethiophosphoramide (**ThioTEPA**) is a cancer chemotherapeutic member of alkylating group. It is obtained by condensation of aziridine with thiophosphoryl chloride. It is mostly used to treat breast cancer, ovarian cancer and bladder cancer. It is also used as conditioning for Bone marrow transplantation.

3.3.3. Cyclophosphamide



b. A second mechanism alkylating agents cause DNA damage in the formation of cross-bridges. Two bases are linked together that has two DNA binding sites.Thus cross-linking prevents DNA getting separated for synthesis or transcription. E.g.: **Cyclophosphamide**

Nitrogen mustards - *Cyclophosphamide

Cyclophosphamide (cytophosphane) is a nitrogen mustard alkylating agent, from oxazophorines group. Condensation of phosphoryl-chloride with di-2-chloroethylamine and further condensation with 3-aminopropanol. It is used to treat various cancers and some autoimmune disorders. It is a "prodrug"; it is converted in the liver to active forms .

7) Antibiotics: bind to DNA and inactivate it. Thus no RNA is synthesized.

8) Mitotic disrupters: Plant alkaloids prevent cell division or mitosis.

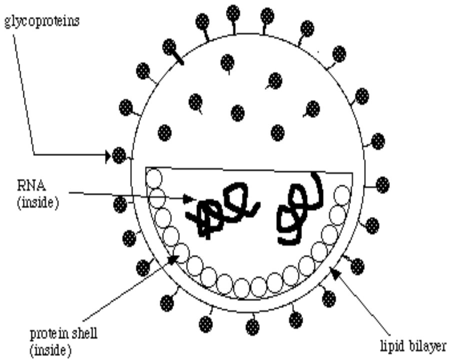
E.g.: Vinca alkaloids – Vinblastin and Vincrystinine.

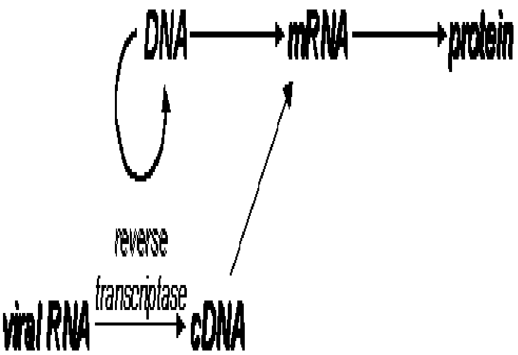
3.4. Acquired Immuno Deficiency Syndrome AIDS

AIDS is caused by *Human Immunodeficiency Virus HIV*.

3.4.1. The infection generally spreads by the following causes:

1. By sexual intercourse.
2. By infected blood, blood products, donated semen and organs.
3. By contaminated needles used.
4. From an infected mother to her child – through the placenta or by breast milk.





AIDS developments

1. People who are HIV positive are seemingly in good health for several years.
2. Soon after the infection, there may be an acute influenza-like illness with no special features and the person becomes seemingly healthy.
3. During this long asymptomatic phase of illness, HIV is replicating in macrophages and CD4+ T-cells but the body replaces all the cells lost through virus infection.
4. By this time HIV infected person can transmit HIV through blood or sexual contact.

AIDS identification

When AIDS develops, main complications are wide spread in the following manner

(a) On the first signs of illness, there is chronically swollen lymph nodes and CD4+

T-cell numbers drop dramatically, eventually immune system begins to fail.

(i) by bacteria – nausea, diarrhoea or recurrent infection of alimentary canal.

  - ii) by fungi – eczema, impetigo, psoriasis, wearts etc.
  - (iii) by other virus – pnemonia, swollen epidermis (such as cytomegalovirus).

(b) In full blown AIDS the HIV virus can infect all cell types including cells in the brain and central nervous system causing neurological diseases and dementia.

  - (i) deteriation of neurological function, forgetfullness, loss of concentration, confusion, limb weakness etc.,.
  - (ii) non-infective enlargement of lymp nodes, malignant tumrous (rare) etc.,.

(c) Additionally, several types of tuberculosis are associated with late stage AIDS .

3.4.2. Prevention

HIV entered into Indian sub-continent by 1980 and the epidemic spread started by 1985. There is as such no cure for AIDS. Some anti-HIV drugs are also not successful for they are highly expensive and can cause hazards. Thus HIV infections can be stopped by preventive measures - through mass media, educating people etc,.

Some of the measures are:

1. One of the main cause of the AIDS is through sexual intercourse and thus the people should be warned against all illegal sexual contacts and multiple sex partner life. The use of condoms may be useful.
2. Another measure is the “Blood safety”. i.e. the blood transfusion should be perfectly checked to be HIV free. Though the legal organisations follow the law under “The Drugs and cosmetics Act”, people should avoid illegal traders.
3. HIV spread is also possible by contaminated needles. The use of disposable syringes alone protect from HIV.
4. Finally the potential infection sources (hospitals etc,)should be properly disinfected.

3.4.3. Control

Though there is no cure for HIV, the drugs may postpone AIDS symptoms and prolong life.

1. Azidothymidine (AZT); 2. Dideoxyinosine (DDI); and 3. Dideoxy cytidine (DDC). These drugs are toxic and expensive. The government is on the way to make it effective and safe. AIDS is a reality in India. Realizing the importance of the HIV infection, the people should respond to the National

Aids committee and the board for AIDS control. The present scientific world is trying its level best to form a vaccine against HIV infection.

Indian medical plants

From time immemorial, man have had the nature as his friend, philosopher and guide. He also tasted the nature as the cure for many of his problems. Plants are one of the nature's gift for mankind as medicines. In India all medical practitioners used herbal medicines. The traditional medicine programme by WHO, called NAPRALERT (Natural product alert) data base was set up at Chicago centre in 1975 for survey and are tabulated under three headings:

1. Medicinal plants as drugs for different diseases.
2. Medicinal use of spices.
3. Medicinal use of Kitchen garden plants.

3.5.1. Examples.

1. Medicinal plants as drugs for different diseases.

Botanical Name	Common Name jÄœ bga®	Therapeutic Use (According to WHO)
Acacia nilotica	Gum Arabic Tree கருவேலமரம்	Demulcent, gonorrhoea, leucorrhoea, styptic, diarrhoea, dysentery, diabetes,
Adhatoda vasica	Malabar Nut ஆடாதோடை	Syrup for bronchitis, whooping cough . immune system-booster.
Allium sativum	Garlic பூண்டு	To control excess conversion of lipids & cholesterol; to prevent cardiac strokes.
Asparagus racemosus	Asparagus; தண்ணீர் விட்டாண் கிழங்கு	To nourish the female reproductive system, promote lactation.
Azadirachta indica	Neem வேப்பமரம்	anti-bacterial, anti-fungal, for skin boils. blood purifying & immune-booster.
Chinchona	Chinchona	For anti-malarial drug.

nilgiris	சின்கோனா	
Cinnamomum zeylanicum	Cinnamon லவங்கப்பட்டை	It is an astringent, gastic irritation, tooth ache and head ache. However it is an important cancer drug.
Eucalyptus globulus	Eucalyptus யூகாலிப்டஸ்	External:deodorant, for skin disorders, analgesic for muscular and joints pain; INTERNAL:digestive, antipyeretic.
Ficus bengalensis	Banyan tree ஆலமரம்	For nausea, diarrhoea, dysentery, haemorrhages, bleeding, discoloration of skin. For leucorrhoea, vaginal white discharges, anomaly of urine, increases fertility in women
Jasminum officinale	Jasmine மல்லிகை	For burning pain wounds,anomaly of blood, For oral & tooth ache, headache, migraine, OIL: cold, heals wounds in skin, head and ophthalmic disorders, stomatitis.
Mimosa pudica	Sensitive plant தொட்டால் சுருங்கி	For gynaecological disorders, skin disorders, bleeding piles, amoebic dysentery, diarrhoea.
Nyctanthes arbortristis	Oleacea பாரிஜாதம்	As anti-tumour activity from the active ingredient of the seed.
Phyllanthus amurus	Phyllantha கீழாநெல்லி	As antiviral drug of Hepatitis B and waste eliminators
Vinca rosea	Winkle plant நித்யகல்யாணி	Vincristin and Vinblastin isolated for the treatment of Cancer

2. Medicinal use of spices

Botanical Name	Common Name jÄœ bga®	Therapeutic Use (According to WHO data)

Pimpinella anisum	Anise சோம்பு	Linnseed/Fruit is a stimulant, carminative diuretic and anticholic
Ferrula asafoetida	Asafoetida பெருங்காயம்	Used as carminative, antispasmodic, digestive, sedative, expectorant, diuritic.
Carum copticum	Caraway ஓமம்	Heirn seeds are used in water dilute for diarrhoea, dysentery, cholera, colic, indigestion, migraine and free respiration.
Elettaria cardamomum	Cardamom ஏலக்காய்	Used as seed or oil for piles, asthma, headache, ear ache, tooth ache. For infections in bladder, liver and uterus.
Capsicum frutescens	Chillies மிளகாய்	For digestive fire, for loss of appitite, indigestion, fltulence and snake bite.
Cinnamomum zeylanicum	Cinnamon லவங்கப்பட்டை	It is an astringent, carminative, stimulant. Used againt nausea, vomiting, gastric irritation, tooth ache and head ache.
Trigonella foenum	Fenugreek வெந்தயம்	Seeds are drugs for anemia, gout and diabetes; extract for fever, peptic ulcers.
Allium sativum	Garlic பூண்டு	To control excess conversion of lipids & cholesterol; to prevent cardiac strokes.
Papaver somniferum	Poppy கசகசா	The seeds are drugs for dry thursts, fever. also controls inflammation of the stomach, dysentery and pain.
Piper nigrum	Pepper மிளகு	It is a stimulant, carminative, digestive. Also used in paralytic, arthritic,

		aches.

3. Medicinal plants in the kitchen garden

Botanical Name	Common Name jÄœ bga®	Claimed Therapeutic Use (According to WHO)
Coriandrum sativum	Coriander கொத்தமல்லி	Leaves –carminative, antibilious. Seeds-stimulants, diuretic, antispasmodic Oil – rheumatism and neuralgia.
Zinziber officinale	Ginger இஞ்சி	For digestive disorders, low appetite, nausea, vomiting, constipation.
Trigonella foenum	Fenugreek வெந்தயம்	Seeds are drugs for anemia, gout and diabetes; extract for fever, peptic ulcers.
Allium cepa	Onion வெங்காயம்	As stimulant, diuretic, expectorant. For anemia, aches, piles, and heart attack.
Allium sativum	Garlic பூண்டு	To control excess conversion of lipids & cholesterol.
Oscimum sanctum	Indian penny wort வல்லாரை	To nourish procencephalon and memory.
Azadirachta indica	Neem வேப்பமரம்	Extract - skin disorders, anti-bacterial, Flower - blood purifying & immune-boosting properties.

3.5.2.Tulasi

This is an erect, softly hairy, aromatic herb found throughout India. *Ocimum tenuiflorum* (*Ocimum sanctum*, or துளசி), is a well known aromatic plant in the family Lamiaceae. It is used as a medicinal plant, and has an important role within many traditions of Hinduism. Native to India, it is a short lived perennial herb or small shrub, often grown as an annual. The foliage is green or purple, strongly scented. Leaves have petioles, and are ovate, up to 5cm long, usually somewhat toothed. Flowers are white, tinged purple, borne in racemes.

Use as medicine.

The leaves are expectorant, anti-periodic and aromatic. Their decoction or infusion is given in malaria, gastic diseases for children and for liver disorders. Fresh leaves are used as drug along with black peper as prophylactic against malaria. The leaf extract is given in chronic fever, haemorrhage, dysentery and dyspepsia. It is also used to check vomitting. Presently it is used as a mosquito repellant apart from using anti-alergic for mosquito bites.

3.5.3. Kilanelli

This is a small plant of one foot and commonly found in wet grounds and as a winter herb.

Phyllanthus amurus (கீழாநெல்லி) is a herb with small leaves dhal shape. The fruits are like small mustard seeds, green in colour clinging to the stem underneath the leaves.

Use as medicine.

It is a common herb known to all in India and are used in cases of urinary troubles like swelling in bladder. It is commonly used as a drug for jaundice, excess-heat and bile in the body. It is an indispensable Indian medicine for antiviral drug of Hepatitis B and urinary waste eliminator. It is also used in Siddha medicine for treating gout, ear-ache, dysentery, menstrual disorders.

3.5.4. Mango

The mango is a tropical fruit of the mango tree. It belong to *Mangifera indica* (மாமரம்) of tropical fruiting trees in the flowering plant family Anacardiaceae. Mango is of South Asian origin. Mangoes retain a special significance in the culture of Hindus and leaves are used for the rituals. It is the national fruit of India. The ripe mango fruits contain glucose, fructose and sucrose. Apart from fibrous proteins, vitamin A, B complex,C and E are also seen with pottacium salt. However unripe mango contains citric, malic oxalic and succinic acids.

Use as medicine.

Raw mango or as pickle is sour, tasteful; it increases appitite and digestive fire. The riped mango fruit is sweet, increases semen quality and works as an appetiser, wound healer, anomaly of blood, heat apoplexy. Mango juice is a restorative tonic.

3.5.5. Semparuthhi

Hibiscus rosa sinunsis (Gumamela, செம்பருத்தி) is a large shrub of the family Malvaceae and cosmopolitan. The leaves are alternate, simple, ovate to lanceolate, often with a toothed or lobed margin. The flowers are large, conspicuous, trumpet-shaped, with five petals, ranging from white to pink, red, purple or yellow, and from 4-15 cm broad.

Use as medicine.

The pollen dust of the flower have been used for curing heart problems, strengthen arteries and remove debility. Its flower has antifungal, emmenagogue, emollient and refrigerant effect. The extracts of red flowers and leaves can be used like shampoo or mixed with oil to be applied on hair to tackle hair-fall and dandruff. The bark of white hibiscus in fruit mixture is the best medicine for the irregular discharges of the menstrual cycle in ladies. Various decoctions of roots cure constipation and cools the digestisve system.

3.5.6. Adadodai

Adhatoda vasica (*Justicia adhatoda*, ஆடாதோடை) is a medium size tree. Its leaves are neither big nor small. Its flowers are white with long petals. The leaf extract has irritating smell with bitter taste.

Use as medicine

The herb is a germi-check drug and regulate urine discharges. It also cures rheumatic problems. However it is a well known drug for bronchitis, whooping cough and immune system-booster.

3.5.7. Thoothuvalai

Solanum trilobatum (தூதுவளை) is a creeper and spreads on the floor with thorny leaves. It has red flowers and small red fruits (when riped). It is an important medical plant in all Indian medical fields including home remedies.

Use as medicine

The decoction of leaves, roots and stem of this creeper is given as a drug for cough, throat infections, Phlegm congestion. It is considered to strengthen the central nervous system.

3.6. Essential oils

The fruits, flowers, leaves, stems, barks and roots of most of the plants have some smell or other. Essentially in fruits, the pleasant smell is due to certain steam volatile oils called essential oils. These may be a single constituent or mixtures of hydrocarbons and their oxygenated derivatives. Majority of these essential oils are the terpenoids (C_1 to C_{15}) and their oxygenated derivatives are alcohols, aldehydes and ketones /their chain constituents.

3.6.1. Examples

1. Single constituent

Oil of Bitter almonad - C_6H_5CHO, Benzaldehyde

Oil of Wintergreen - Methyl salicylate.

2. Mixtures of hydrocarbons and their oxygenated derivatives

Turpentine	Pinene
Citronella	Citronellal, geraniol
Coriander	Pinene, linalool
Geranium	Geraniol esters, citronellol
Jasmine	Linalool
Lemon	d-Limonene, citral
Sweet orange	d-Limonene
Peppermint	Menthol and its esters
Sandal wood	Santalol
Cardomum	Terpineol
Camphor	Camphor
Ginger	Zinziberene

Due to the pleasant smelling nature, some of the mono and sesquiterpenoids are of high commercial importance in the perfume industry.

3.6.2. Isolation of essential oils from plants

A large number of plant species contain chemical compounds which can be isolated as an essential oil. Different methods are used to isolate these oils from the various plant materials. Although it seems relatively simple to isolate such oils, the composition of an oil, the quantity extracted may vary depending on the isolation method used. The following methods are usually used in the isolation of essential oils.

1. Expression
2. Steam distillation
3. Extraction by means of volatile solvents
4. Adsorption in purified fats (enfleurage)

3.6.2.1. Different methods

Expression method:

The plant material is crushed and the extract is centrifuged in a high speed when nearly half of the essential oil is extracted. The other half of the oil is left and the residue is used for the isolation of inferior quality of oil by distillation. E.g.: Citrus, Lemon and Grass – oils.

Steam distillation:

The plant material is macerated and then steam distilled when the essential oils go into distillate from which they are extracted by the used of pure organic volatile solvent, like light petrolium. Though this is the common process used, some quantity of oil is decomposed during distillation and some (esters) are hydrolysed to non-fragment and less-fragment (combined molecules) compounds.

Extraction by means of volatile solvents:

This is an improved method over the steam distillation. Here the plant material is directly treated with light petrol like volatile solvents at 50^o to 60^o C and the solvent is then removed by distillaltion under reduced pressure.

Adsorption in purified fats (enfleurage):

The fat is taken in glass plates. It is warmed to about 50^{o}C. The surface is covered by the petals (the solft materials of the plant) and allowed to dryout from the essential oils. The plant parts may be replaced periodically. When the fat is getting saturated with the essential oils of the plant part, it is digested with ethyl alcohol. The extract having ethyl alcohol and essential oil is distilled under reduced pressure to remove the solvent.

The alternate methods:

Presently the activated charcoal (Coconut charcoal) is used in place of fat for it shows greater stability and more surface compared to fat.

3.6.3. Natural Perfumes

Perfume is a mixture of fragrant essential oils and aroma compounds, fixatives, and solvents used to give the human body, objects, and living spaces a pleasant smell.

3.6.3.1.Examples:

Plant sources

Plants have long been used in perfumery as a source of essential oils and aroma compounds. These are secondary metabolites of plants to protect against herbivores, infections and to attract pollinators. The sources may be derived from various parts of a plant.

E.g.: (i) Aerial portions and seeds of coriander have different odors – different essential oils.

(ii) a.Orange leaves - petit grain; b. blossoms – neroli; and c. fruit zest - orange oils.

Bark: Barks are used to extract the essential oil to make perfumes.

- Commonly used barks includes cinnamon and cascarilla and Sassafras root bark.

Flowers and blossoms: Undoubtedly the largest source of aromatics.

- Includes the flowers of rose and jasmine, osmanthus, mimosa, tuberose.
- The blossoms of citrus and ylang-ylang trees.
- The unopened flower buds of the clove.

Fruits: Fresh fruits-apples, strawberries, cherries do not yield perfum

- Citrus such as oranges, lemons, and limes yield perfumes.

Leaves and twigs: Leaves and twings with fine odours are major sources of essential oil

- Common perfumes - lavender, patchouli, sage, violets, and citrus leaves.
- Leaves are valued for the "green" smell - hay and tomato leaf.

Resins: These resins have been widely used in incense and perfumery.

- Highly fragrant and antiseptic resins - Peru balsam, gum benzoin.
- Resin for perfumes -labdanum, frankincense/olibanum, myrrh.
- Pine and fir resins - valued source of terpenes for organic synthesis of aromatics.
- The resinous secretion of fossil conifer perfumery - amber and copal.

Roots and rhizomes: Commonly used terrestrial portions in perfumery include:

- Iris rhizomes, vetiver roots, various rhizomes of the ginger family.

Seeds: Many seeds include the basis for perfume synthsis by yielding essential oils.

- Tonka bean, coriander, caraway, cocoa, nutmeg, mace, cardamom, and anise.

Woods: Very important in making the base notes to a perfume are wood oils.

- Woods for oils - sandalwood, rosewood, agarwood, birch, cedar, juniper, and pine.

Animal sources

Animal extracts are always used in minute concentrations because of their overpowering odour. When they are diluted to the right proportion, they give glorious fragrances.

Ambergris: Lumps of oxidized fatty compounds, whose precursors were secreted and expelled by the Sperm Whale is called Ambergris.

Castoreum: Obtained from the odorous sacs of the North American beaver.

Civet: Also called Civet Musk, this is obtained from the odorous sacs of the civet cats.

Honeycomb: From the honeycomb of the Honeybee both beeswax and honey are solvent extracted to an absolute. Beeswax is extracted with ethanol and then to beeswax absolute. **Musk**: Musk, derived from the musk sacs of the Asian musk deer, is called "white musk".

Other natural sources

Lichens: Commonly used absolutes are from lichens - oakmoss and treemoss thalli.

Seaweed: Seaweed distillates are sometimes used as essential oil in perfumes. *Fucus vesiculosus,* which is commonly referred to as bladder wrack perfume.

3.6.3.2. Production of Natural perfumes

1. Preparation of materials for isolation of essential oils

Natural flavor or fragrance can be produced by using a "unicellularized plant", obtained by unicellularizing, without destroying the cells of a plant usable as a starting material. It is:

- Isolated by enzymatic treatment or chemical treatment or continuously heating
- Isolated directly as natural flavor or fragrance in short aging period, or
- Isolated by homogenizing it as the starting material quickly after harvesting.

2. Mechanism of Natural perfume production

The chemical compounds present in plant species can be isolated as an essential oil in the following manner. Different isolation methods such as hydrodistillation, solvent extraction, and simultaneous distillation-extraction are the processes to end with the essential oils. It is also possible by extraction by supercritical carbon dioxide, and the use of microwave ovens.

3.6.4. Flower perfumes

The essential oil in plants, which give them their particular aromas, are found in flowers. The costliest and finest of perfume oils, called the "absolute," are obtained from these flowers. The natural oils of the rose, jasmine, and orange flower are the most important.

3.6.4.1. Examples :

1. Roses

One of the most valuable elements of a fine perfume is provided by the rose, known as the "queen of flowers". Roses are gathered at night since they are at their most fragrant before sunrise. The two main species of roses used in perfume are the *Rosa centifolia* and the *Rosa damascena*. **Rose perfume** are found in 75% of all perfumes.

2. Jasmine

Jasmine, another "absolute," or pure essence, gives a perfume a well-rounded, finished quality. Jasmine flowers are harvested when their scent is at its peak just before dawn. The flowers must be processed immediately before their freshness fades. They are placed in special baskets to prevent bruising and unbalancing of natural bouquet. Eight thousand jasmine flowers yield 1/25 oz of absolute of **Jasmine perfume.**

3. Violets

Violets have been used in perfumes throughout the ages. They used violet in both perfumes and medicines. It has been used for cures from headaches to cures for cancer. There are two varieties of violets used in perfumes, the *Victoria violet* and the *Parma violet*. Violets only produce a scant amount of essential oils, and are rarely used to produce **Violet perfume**.

4. Orange The orange flower is the traditional flower of brides all over the world. The bitter orange is one of the most versatile trees producing the essential oils for this scent. Its blossoms provide orange flower absolute. Orange flower oil or "neroli" was named after the Italian Princess of Neroli. The absolute is somewhat scarce, but Neroli oil, **Orange perfume**, the dilute is plentiful and widely used, especially in finer citrus colognes.

3.6.5. Flavours and Fruit flavours

Flavor or flavour is the sensory impression of a food or other substance, and is determined mainly by the chemical senses of taste and smell. These are minor constituent of food and non-nutritive and are unstable to heat. The flavour of the food, as such, can be altered with natural or artificial flavourants, which affect these senses.

3.6.5.1. Examples

A natural flavour is the essential oil, oleoresin, essence or extractive, protein hydrolysate, distillate, or any product of roasting, heating or enzymolysis, which contains the flavoring constituents derived from a spice, fruit or fruit juice, vegetable material or fermentation products thereof, whose significant function in food is flavoring rather than nutritional."

Banana flavour - *Musa indica*

Banana (many species) has historically been difficult to extract juice from the fruit because when compressed, banana simply turns to pulp. In 2004, BARC, India, patented a technique for extracting juice by treating banana pulp in a reaction vessel for four to six hours. The extracted juice is centrifuged to make Banana concentrate. Banana Concentrate is all made of natural ingredients, rich in vitamins, and usefull making a wide spectrum of Desserts and Drinks. Concentrates are used in any kind of a Cocktail, Sorbet, Mix, Non-Alcohol drink.

Grapefruit flavour - *Citrus paradisi*

Grapefruit essential oil is cold-pressed from the rind of ripe grapefruit. It is a yellow liquid with a fresh, sweet citrus aroma, which is considered uplifting and refreshing. Grapefruit is cooling, cleansing, and decongestive, and can be beneficial for an overheated liver and sluggish lymph system. Key constituents of the oil are Limonene (90%) and Myrcene (4%). Like many of the citrus oils, it has a unique 'fat dissolving' characteristic.

Orange flavour - *Citrus aurantium*

The orange fruit is earth shaped with rough skin. It is cold pressed and expressed to extract the orange essential oil. The peel oil is oil of Bigarade and the sweet orange oil is oil of Portugal. Orange Concentrate is all made of natural ingredients, rich in vitamins, and useful making a wide spectrum of Desserts and Drinks. It is well used for cold, constipation and flatulence. These are like drugs for gums and alimentary canal. The induce slow digestion and release stress.

Apple flavour - *Malus indicus*

Apple tree is the symbal of prosperity and the tree is a small with branches full of buds, flowers and in seasons fully ripened fruit. The fruits are macerated and then steam distilled when the essential oils go into distillate from which they are extracted by the used of pure organic volatile solvent. This oil can be canned, juiced and optionally fermented to produce apple juice, cider, vinegar and pectin. The cider corrects intestinal flora, reduces stomach acidity, corrects gas, and helps the kidneys. Apple cider vinegar and water make a rinse to restore hair, scalp and skin. Apple cider vinegar, water, and honey aid digestion.

Strawberry flavour - *Fragaria ananassa*

The Garden strawberry is the most common variety of strawberry cultivated worldwide. The fruit is an accessory fruit with hypanthium fleshy part. It is cold pressed and expressed to extract the strawberry essential oil. Strawberries are a popular addition to dairy products, as in strawberry flavored ice cream, milkshakes, smoothies and yogurts. Strawberry pie is also popular. Strawberries can also be used as a natural acid/base indicator. They are also used in cereal bars. They are also supposedly used for whitening teeth. One cup (144 g) of strawberries constitutes 45 calories and is an excellent source of vitamins and amino acids.

3.6.6. Artificial flavours

Owing to the increase in world population and the consequent use of food from non-traditional sources, the need for these flavouring agents has increased. Due to the high cost or unavailability of natural flavor extracts, most commercial flavorants are nature-identical, which means that they are the chemical equivalent of natural flavors but chemically synthesized rather than being extracted from the source materials. Many flavour compounds are in the form of esters and several esters are often mixed to produce a particular flavor. Some common flavors are: banana - isoamyl acetate; cinnamon - ethyl cinnamate; orange - octyl acetate; pineapple - methyl butyrate; pear - isoamyl butyrate; and wintergreen - methyl salicylate.

3.6.6.1. Examples

Grape flavour is well expressed with methyl anthranilate. Acetophenone helps create a better Black Cherry flavor and acetaldehyde, ethyl butyrate and hexanal all add to the character of orange juice. For example, benzaldehyde gives almond flavour.

Common flavours used around in the soft drinks. (esters)

Phenyl lactate	Banana

Butyl lactate	Straberries
Octyl acetate	Orange
Pentyl valerate	Apple.

3.7 Waxes

Waxes may be natural secretions of plants or animals or artificially produced by purification from natural petroleum or completely synthetic. Beeswax, paraffin (a petroleum wax) are common. A wax is a lipid having variety of long-chain alkanes, esters, polyesters and hydroxy esters of long-chain primary alcohols and fatty acids. They are distinguished from fats by the lack of triglyceride esters and fatty acids. Paraffin waxes are hydrocarbons, mixtures of alkanes usually in a homologous series of chain lengths.

3.7.1. Classification of waxes

3.7.1.1. Animal waxes – Animal waxes, found on their skin, hair etc.,. for protection.

- Beeswax - produced by honey bees. It is from honey comb and is made up of esters of ceryl myristate **$C_{13}H_{27}$-COO-$C_{26}H_{53}$** and myricyl palmitate **$C_{15}H_{31}$-COO-$C_{30}H_{61}$.** It also contains straight-chain alkanes such as n – $C_{21}H_{44}$ and n – $C_{29}H_{60}$. It melting point is 62-65$_o$C. It is used to make shoe polishes, candles and paper coatings.
- Spermaceti - from the head cavities and blubber of sperm whale. This is obtained by chilling the extracted oil of the whale. Its melting point is 42- 50^{o}C. It consists of cetyl palmitate **$C_{15}H_{31}$-COO-$C_{16}H_{33}$**. It is white, odourless and tasteless. It is used as a base for ointments and cosmetics. It is also used for making candles.
- Shellac wax - from the lac insect *Kerria lacca*.
- Chinese wax - produced by the scale insect *Ceroplastes ceriferus*.
- Lanolin (wool wax) - from the sebaceous glands of sheep.

3.7.1.2. Vegetable wax-It is found on leaves, stems and fruits; protect from dehydration etc. Candelilla wax - from Mexican shrubs *Euphorbia cerifera* and *E. antisyphilitica.* This vegetable wax is hard, but soft and less brittle. This wax is brown in colour and it may be refined to get light yellow wax. It is mainly used in electrical insulating compositions for its good dielectric properties.

- Carnauba wax - from the leaves of the Brazilian Carnauba palm *Copernica cerifera*. It contains several components including myricyl cerotate **$C_{25}H_{51}$-COO-$C_{31}H_{63}$.** On hydrolysis gives myricyl alcohol **$C_{31}H_{63}$OH** and certotic acid **$C_{25}H_{51}$COOH.** It melts between 80-87^{o}C.

It is very hard and impervious to water and is used in automobile, floor polishes, as a coat in carbon paper and mimeograph stencils.

- Castor wax - catalytically hydrogenated castor oil.
- Jojoba oil – equal to spermaceti. From the seeds of jojoba, *Simmondsia chinensis*.
- Soya wax - from soybean oil.

3.7.1.3. Mineral waxes

Minerals and other subsoil products yielding waxes.

- Parafin wax – It is the mineral wax derived from petrolium during distillation process.
- Montan wax - extracted from lignite and brown coal.

3.7.1.4. Synthetic waxes

These synthetic waxes are having straight chain hydrocarbon produced by the Fischer-Tropsch process. These provide excellent slip and rub properties but are different in appearance. They are economical, cheap; used in ink, paint and coating.

- Polyethylene wax - based on polyethylene and polymerized α-olefins.
- Opal waxes – consists of hydrogenated fats and melts above 70^{o}C.
- Lanette waxes - usually esterified or saponified high molecular weight alcohols.

3.7.2. Manufacture of candles

A mixure of stearic acid and palmitric acid is used with about 50 to 85% paraffin wax of melting point around 55^{o}C for the manufacture of candles. The mixture of fatty acids obtained by hydrolysis of fats with super heated steam is heated to about 60^{o}C and pressed when liquid acids are separated. The solid cake, called stearine, is obtained and is a mixture of stearic acid and palmitic acids. It is mixed with proportional paraffin wax and melted. The molten mixture is poured into metal tubes carrying twisted cotton threads to act as wicks (threads are defatted, bleached and soacked in ammonium phosphate, ammonium choride and borax to avoid smouldering). The candles are removed from the tubes and their outer surfaces are polished mechanically for commercial purposes.

3.7.3. Uses of waxes

1. Wax added with coloured pigments has been used as a medium in encaustic painting, and is used today in the manufacture of crayons and coloured pencils.

2. Waxes are used to impregnate or coat paper and card to waterproof or make it resistant to staining or to modify its surface properties.
3. Waxes are also used in wax polishes for furniture, wood products, footwear and vehicles; as agents in mould making to waterproof leather and fabric.
4. Wax are used as a temporary, removable model in casting of gold, silver etc.,.
5. Wax candles are used for lighting, signals in warfare, safety in travel.
6. Carbon black suspended montan wax, is used for carbon paper, photocopiers.
7. Lipstick and mascara are blends of various fats and waxes of coloured pigments
8. Both beeswax and lanolin are used in cosmetics.

3.7.4. Soaps and detergents.

Soap is a surfactant used in conjunction with water for washing and cleaning; it is available in solid bars and viscous liquids. Decorative soaps are used for human hygiene. Chemically, soap is a Sodium/Potassium salt of a higher fatty acid. Many cleaning agents today are technically not soaps, but detergents, which are less expensive and easier to manufacture. Detergent is a compound, or a mixture of compounds, intended to assist cleaning.

3.7.5. General consideration of soap making

Soap is made by saponification between a fat and a strong alkali like lye (sodiumhydroxide), potash (potassium hydroxide), or soda ash (sodium carbonate). i.e. the alkali and water hydrolyze the fat and convert it into free glycerol/glycerin and soap i.e. fatty acid salt. It commonly refers to the reaction of a metallic alkali (base) with a fat or oil to form soap. If Sodium hydroxide, the alkali, ($NaOH$) is used a hard soap is formed, whereas when potassium hydroxide, the alkali, (KOH) is used a soft soap is formed. Vegetable oils(fats) and animal (oil) fats are fatty esters in the form of triglycerides. The alkali breaks the ester bond and releases the fatty acid and glycerol. Soaps may be precipitated by salting it out with saturated sodium chloride.

3.7.6.Manufacture of Soaps and Detergents

Soap and detergent manufacturing consists of a broad range of processing and packaging operations. Cleaning products come in three principal forms: bars, powders and liquids. Some liquid products are so viscous that they are gels. The first step in manufacturing all three forms is the selection of raw materials. Raw materials are chosen according to many criteria, including their human and environmental safety, cost, compatibility with other ingredients, and the form and performance characteristics of the finished product. While actual production processes may vary from manufacturer to manufacturer, there are steps which are common to all products of a similar form.

I. Soap manufacture

Soaps are made from fats, oils or fatty acids with inorganic water-soluble bases.

1. The main sources of fats/oil are:

(i) beef and mutton tallow; (ii) coconut and palm kernel oils (iii) Ground nut oil

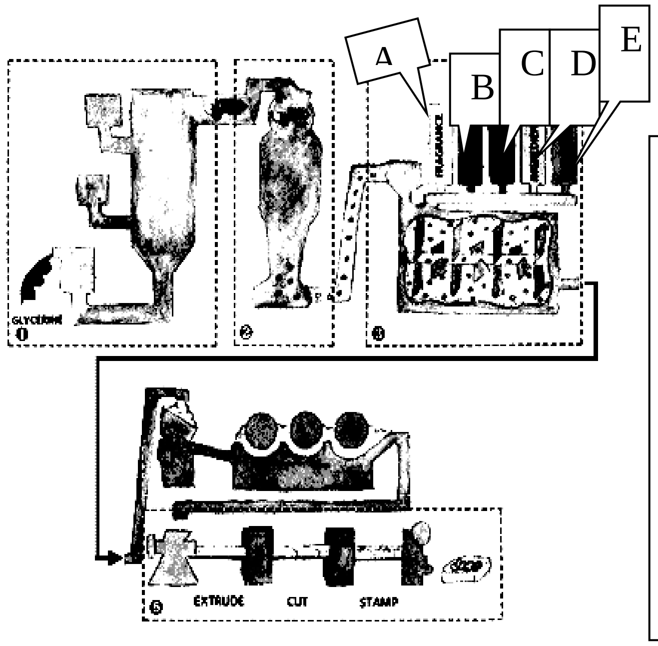
2. The raw materials may be pretreated to remove impurities and to achieve

(i) the color, (ii) odor and (iii) performance features desired.

3. The chemical processes for making soap: i.e., Saponification is the hydrolysis of an ester in basic conditions to form an alcohol and salt of a carboxylic acid.

CH2-OOC-R - CH-OOC-R - CH2-OOC-R (fat) + 3 NaOH (or KOH) both heated →

CH2-OH -CH-OH - CH2-OH (glycerol) + 3 R-CO2-Na (soap) (R=(CH2)14CH3 as an E.g)



A. Fragrances.
B. Colourants.
C Other ingradient – (i).
D. Other ingradient – (ii)
E. Other ingradient – (iii)

① Glycerine expeltion.
② Soap pellet precipitation.
③ Amalgamation of extra- ingradiants.
④ Blending the texture.
⑤ Final Soap Cake.

Presently soap is made by continuous processes for the flexibility, speed and economics.

① The oil or fat is heated with steam in large iron pan and 10% NaOH solution is added in thin stream to the boiling mass. Saponification takes place.

Eventually soap in liquid form, is produced with a valuable by-product, glycerine (1). The glycerine is recovered by chemical treatment, followed by evaporation and refining.

②The next processing step after saponification or neutralization is drying. Vacuum spray drying is used to convert the neat soap into dry soap pellets (2). The moisture content of the pellets will vary depending on the desired properties of the soap bar.

③In the final processing step, the dry soap pellets pass through a bar soap/soap cake finishing line. This unit is a mixer, called an amalgamator, in which the soap pellets are blended together with fragrance, colorants and all other ingredients (3).

④The mixture is then homogenized and refined through rolling mills and refining plodders to achieve thorough blending and a uniform texture (4).

⑤ Finally, the mixture is continuously extruded from the plodder, cut into bar-size units and stamped into its final shape in a soap press (5).

II. Detergent manufacture

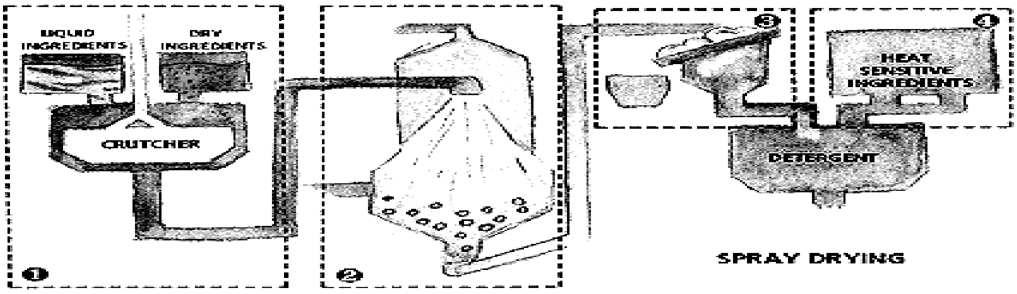
Detergents are produced by spray drying, agglomeration, dry mixing or combinations of all.

In the *spray drying* process, dry and liquid ingredients are first combined into a slurry, or thick suspension, in a tank called a crutcher (1).

The slurry is heated and then pumped to the top of a tower where it is sprayed through nozzles under high pressure to produce small droplets. The droplets fall through a current of hot air, forming hollow granules as they dry

(2). The dried granules are collected at the bottom, screened to make uniform size

(3). After the granules have been cooled, heat sensitive ingredients that are not compatible with the spray drying temperatures (such as bleach, enzymes and fragrance) are added (4).



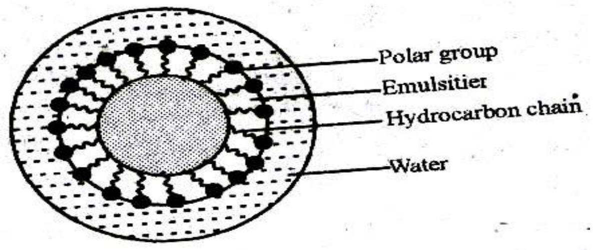
Traditional spray drying produces relatively low density powders. New they have reduced the air inside the granules during spray drying to achieve higher densities. The higher density powders can be packed in much smaller packages than were needed previously.

3.7.7. Action of soaps and detergents

Soaps are useful for cleaning because soap molecules attach readily to both nonpolar molecules (such as grease or oil) and polar molecules (such as water). Although grease will normally adhere to skin or clothing, the soap molecules can attach to it as a "handle" and make it easier to rinse away. Applied to a soiled surface, soapy water effectively holds particles in suspension so the whole of it can be rinsed off with clean water.

(fatty end) :CH3-(CH2)n-CO2- +Na: (water soluble end)

The hydrocarbon ("fatty") portion dissolves dirt and oils, while the ionic end makes it soluble in water. Therefore, it allows water to remove insoluble matter by emulsification.



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Unit - IV

Water, fuels, gases and industrial products

4.1. Water

Water (H_2O, HOH) is the most abundant molecule on Earth's surface. It is about 70% of the Earth's surface as liquid and solid in addition to being found in the atmosphere as a vapor. Saltwater oceans hold 97% of surface water, glaciers and polar ice caps 2.4%, and other land surface water such as rivers, lakes and ponds 0.6%. Without water no life can survive. It is of important for all life process from distribution of nutrition to the elimination waste.

4.1.1. Hard water

It can also be defined as water that doesn't produce lather with soap solutions, but produces white precipitate (scum). Hard water has high mineral content (contrast with soft water). Hard water usually consists of calcium (Ca^{2+}), magnesium (Mg^{2+}) ions, and possibly other dissolved compounds such as bicarbonates and sulphates. There are two types of hardwater.

1. Temporary hardness is caused by a combination of calcium ions and bicarbonate ions in the water. It can be removed by boiling the water or by the addition of lime (calcium hydroxide). Boiling promotes the formation of carbonate and precipitates calcium carbonate out of solution, leaving water that is softer upon cooling.
2. Permanent hardness is hardness (mineral content) that cannot be removed by boiling. It is usually caused by the presence of calcium and magnesium sulphates and/or chlorides in the water, which become more soluble as the temperature rises.

Units expressing the hardness of water

The hardness of water is due to the presence of soluble salts of calcium or magnesium. The degree of hardness is defined as the number of parts by weight of calcium carbonate CaCO3 (or its equivalent) present in million parts (10^6) by weight of water.

'Parts per million weight/volume (ppm w/v or ppm m/v)' .

4.1.2. Treatment of water for domestic purposes

It is estimated that 15% of world-wide water use is for household purposes. These include drinking water, bathing, cooking and sanitation. The water supplied should be colourless, free from particles, impurities, germs, or any other dissolved contant injurious to health.

4.1.2.1. Different methods

Sterilization.

In an emergency and for the domestic purposes, boiling is the best way to purify water before the usage. All problems of microbes and temporary hardness can be removed. The water should be filtered before boiling. Filters for use may be coffee filters, towels (paper or cotton), cheesecloth, or a cotton plug in a funnel. Finally the scales should be removed.

$Ca(HCO_3)_2 \rightarrow CaCO_3 + CO_2 + H_2O$

Exposure to sunlight and ultraviolet light.

The presently the sterilization of drinking water is done by the exposure to sunlight and ultraviolet light. It is preferred over chemical methods for no odour or taste is imparted. Sunlight is helpful in destroying the microbes. However it cannot penetrate large depths. Mercury vapour lamp enclosed in quartz container is used as a source of ultraviolet rays for the sterilization of water. The large plant consists of series of pabble plates arranged in such a manner as to effect repeated passage of water under the influence of ultraviolet rays.

Chemical methods of sterilization.

a. Precepitation methods: Most impurities and supended particles in water can be easily precepitated by the addtion of suitable reagents, such as alum, soda ash, like etc.,.

b. Aeration: The process of aeration consistas in bubbling compressed air through raw water or water for the treatment purposes. Eventually Iron as iron hydroxide, Carbon base gases as Carbon-di-oxide and other precipitates and many other di-oxides from the unwated basic elements are removed. The aeration may be done by flowing a long distance in air, spraying, sprinklin or bublling through the column of water.

c.Ozonisation: Ozone is a relatively unstable molecule "free radical" of oxygen. It readily gives up one atom of oxygen providing a powerful oxidising agent which is toxic to most water borne organisms. It is a very strong, broad spectrum disinfectant. The plant consists of a tower made of enameled iron divided into many compartments by perforated celluloid partitions. At the bottom one inlet is for the water to be treated and the other is for nascent ozone from the ultraviolet light or a "cold" electrical discharge. The perforated partitions enable the mixing for sterilization. The sterilized water is collected by the outlet at the top.

d. Chlorination: The most common disinfection method is use of chlorine or its compounds. Chlorine is a strong oxidant that rapidly kills many harmful micro-organisms. Chlorine is a toxic gas and this problem is avoided by the use of sodium hypochlorite, which is a relatively inexpensive solution that releases free chlorine slowly. The excess chlorine may be removed to avoid toxicity. This is executed by the addion of sulphites, “antichlor”.

5. Chloramine Process

Chloramines are another chlorine-based disinfectant. It is possible to convert chlorine to chloramine by adding ammonia to the water after addition of chlorine:

$2NH_3 + Cl_2 \longrightarrow NH_4Cl + NH_2Cl$; $3NH_3 + 2Cl_2 \longrightarrow 2NH_4Cl + NHCl_2$.

Although chloramine is not a strong oxidant, it does provide a longer lasting residual action with least chlorine taste and odour.

4.1.3. Treatment of water for Industrial purposes

It is estimated that 15% of world-wide water use is industrial. Major industrial users include power plants, which use water for cooling or as a power source (i.e. hydroelectric plants), ore and oil refineries, which use water in chemical processes, and manufacturing plants, which use water as a solvent. It is harmful in the industrial processes.

Disadvantages of using hard water in the industrial puposes

(a) Hard water cannot be used for washing purposes, because a large quantity of water is consumed to clean or laundry work for the salts are to be precipitated and equally not useful for bathing puposes since lather formation is inhibited by the salts.

$2C_{17}H_{35}COONa + CaCl_2 \longrightarrow 2NaCl + (C_{17}H_{35}COO)_2Ca$.

Soap (soluble) (Salt in hard water) (Common salt) (Calclium salt precipitate)

(b)Hard water cannot be used for generating steam in boilers for the boiling makes calcium carbonate etc salts to precipitate insde the boiler and steam pipes as scales. Scales are poor conducter of heat leading to heavy loss of heat and thus the fuel also. Secondly, the crust of scale prevents the transfer of heat and make red hot boilers and pipes allowing sudden crack of scales. Such a change and sudden formation of steam may cause the boiler to burst.

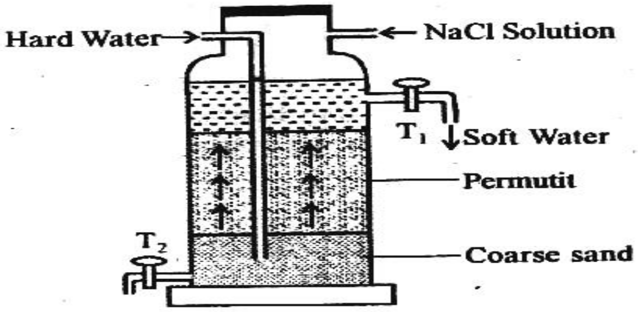
(c) Hard water cannot be used for many industrial purposes for it may cause corrosion. Most of the acid radicals like chlorides are often hydrolysed to produce hydrochloric acid which corrodes the surface of the materials and thus the shortens their life.

$MgCl_2 + 2H_2O \longrightarrow Mg(OH)_2 + 2HCl$.

4.1.3.1. Different Processes

(i) Permutit process

Permutit is an artificial zeolite, complex salt called sodium aluminium othosilicate, $Na_2O.Al_2O_3.\ xSiO_2..\ yH_2O$. This permutit is represented as Na_2Ze (zeolite). It is used to remove permanent hardness in water. It is obtained by fusing together sodium carbonate, alumina and silica. Permutit or zeolite is packed into a column and the hard water is allowed to flow through it. Double decomposition occurs and calcium aluminium silicate is formed exchanging Na^+ ions for Ca^{2+} ions (Similarly for Magnesium). Eventually the permotit is completely converted into its calcium (magnisium) salt. It can be made fit for use again by pouring a strong solution of 10% sodium chloride (brine) through the column.



$Na_2Ze + CaSO_4 \longrightarrow CaZe + Na_2SO_4$

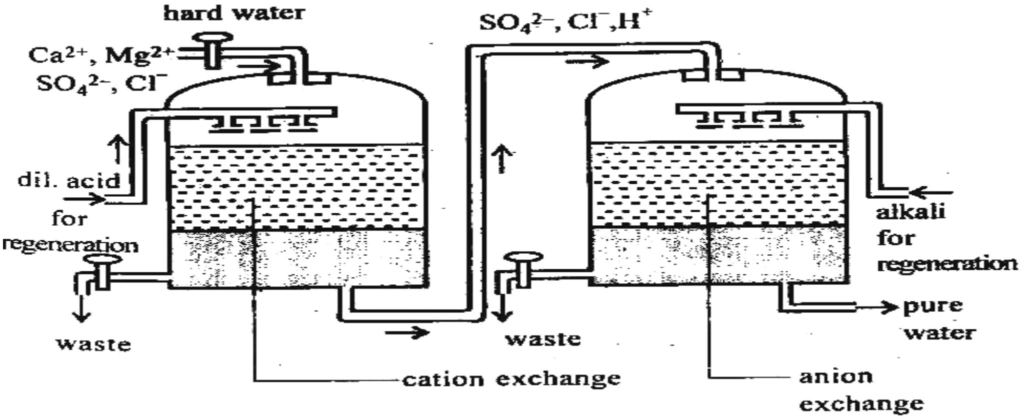
Sodium aluminium silicate+ calcium sulphate ⟶ calcium aluminium silicate+ sodium sulphate
(zeolite) (salt causing hardness of water)

$CaZe + 2NaCl \longrightarrow Na_2Ze + CaCl_2$

Calcium aluminium silicate + sodium chloride sodium Aluminium silicate + Calcium Chloride
(common salt) (zeolite)

(ii) Ion-exchange process

Most typical method for the removal of both types of hardness of water is by means of ion exchangers. Typical ion exchangers are ion exchange resins (functionalized porous or gel polymer), zeolites, montmorillonite, clay, and soil humus. Ion exchangers are either cation exchangers (contains –COOH) that exchange positively charged ions (cations) or anion exchangers (amines) that exchange negatively charged ions (anions). There are also amphoteric exchangers that are able to exchange both cations and anions simultaneously.



Usually the hardwater is first passed through a bed of cation exchange resin (**RH**) which replaces all the metallic ions like Na^+, Ca^{++}, Mg^{++} and others by exchange with H^+. Eventually equivalent amount of H^+ ions are released from the resin into the water.

$$2RH + Ca^{++} \longrightarrow R_2Ca + 2H^+ .$$ (Similarly for Mg^{++} etc.,.)

The water is now acidic with H^+ ions. It is passed through anion exchange resin (**RNH_2**) . The resin combines with water immediately to form ammonium hydroxide.

$$2NH_2^+ + HOH \longrightarrow RNH_3^+OH^-$$

The exchange reaction is activated. All the anions like SO_4^{2-} , Cl^- etc ., present in the water are removed and an equivalent amount of OH^- ions are released from the resin to water.

$$RNH_3^+OH^- + Cl^- \longrightarrow RNH_3^+Cl^- + OH^-$$

$$2\,RNH_3^+OH^- + SO_4^{2-} \longrightarrow (R\,NH_3^+)\,SO_4^{2-} + 2OH^- .$$

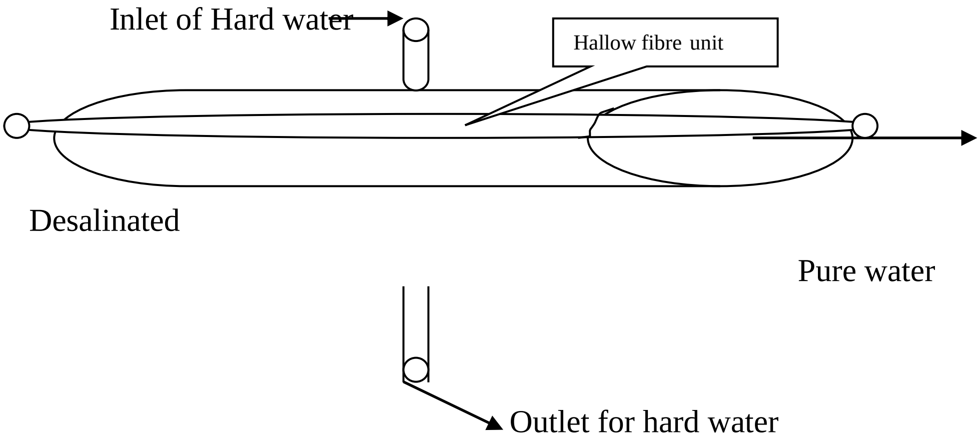
Finally H^+ and OH^- ions released from cation and anion exchange resins combine to produce water . Now the water coming out from the anion exchange resin is totally free from mineral matter, i.e. all types of hardness. This is called deionised water. The exhausted cations exchange resin may be regenerated by passing a solution of dil. HCl or dil. H_2SO_4 and the anion exchange resin is regenerated by passing a solution of dil.NaOH.

(iii) Reverse osmosis

Instead of simple separation of the two solutions by the semipermeable membrane, they can be put in two compartments where they are separated by a semipermeable membrane. The semipermeable membrane does not allow the solutes to move from one compartment to the other, but allows the solvent to move. But when pressure is applied equal to the osmotic pressure of the solution on the dilute solution side, the movement is achieved by the movement of the solvent from areas of low solute concentration to areas of high solute concentration. Eventually the solute concentration will decrease. This is reverse osmosis.

(iv) Desalination of hard water

Areas that have no or limited surface water or groundwater may choose to desalinate any available water to obtain drinking water. Reverse osmosis is the most common method of desalination. The water has to be pretreated in a spiral flow to remove the suspended particles and other materials for accumulated material cannot be removed from membrane surface systems. The hard water is fed into the top of the reverse osmosis cell under pressure. The middle part of the cell consists of a unit of millions of hair like fibres whose walls acts as semipermeable membrane (Nylon, cellulose acetate etc,). RO membranes are made in a variety of configurations (spiral-wound or a hollow-fiber etc.,). Reverse osmosis takes place. Desalinated water is obtained from inside the fibres.



4.2. Fuels

Fuels are combustible substances which are burnt to produce heat energy.

4.2.1. Calorific value of fuels

It is the quantity of heat produced by a given mass of fuel on complete combustion. In SI system, it is in **Kilojoules per kilogram.** In CGS system it is in **Calories per gram.**

4.2.2. Requirements of a fuel

1. It should have high heat content (calorific value).
2. It should not produce undesirable by-products, ash, smoke etc.,.
3. It should be cheap.

4.2.3. Types of fuels

There are 3 types of fuels. They are:

1. Solid fuels. E.g.: wood, coal,coke, charcoal, cowdung cake etc.,.

(a) These are drived from plants directly or indirectly.

(b) These are less economical.

(c) They take a long time to ignite.

(d) They leave ash or some unwanted materials and produce smoke.

(e) There is loss of heat during combustion.

However they are cheap, easy to store and available in plenty (poor man's fuel).

2. Liquid fuels. E.g.: Kerosine, alcohol, petrolium etc.,.

(a) These are economical and produce less smoke and readily ignated.

(b) They need to be processed or distillated before use.

(c) These are fossil fuels (or abiogenic) or synthetic.

(d) The transportation of these fuels are tasks.

However they are to be stored in planned systems and are lost by evoporation (present ruler)

3. Gaseous fuels. E.g.: natural gas, water gas, oil gas etc.,.

(a) These are from fossils, abiogenic products or produced on the spot.

(b) They are easily transportable even by pipe line or tubes.

(c) They are readily ignited, do not leave ash or smoke.

(d) They have high calorific value.

However they are to be tranported or stored in proper system to avoid accidents.

4.2.4. Refining of crude pretroleum

Petroleum is a dark coloured crude oil that occurs naturally at variable depths below the surface of the earth. It is made of hydrocarbon molecules like alkanes, cycloalkanes, and many aromatic compounds (benzene). Small amount of oxygen, nitrogen and sulphur are also seen. Crude oil is extracted from the ground in several processes. Primarily the oil is decolourised by bauxite. The fractional distillation of this oil into different important fractions and the removal of undesirable material is called refining.

Each hydrocarbon boils at a definte temperature. The oil is heated in a tall cylindrical steel furnace. The high boiling fractions cool off and condense in the lower part of the tower. The low boiling fractions condense in the upper part of the tower. The gaseous matters such as methane, ethane and propane escape at the head of the tower. Then a final residue called petroleum coke or pitch collects at the base of the tower.

Table of Products: The details of fractions and their characteristics with use.

S.No.	Fractions	Boiling range ^oC	Uses
1.	Gaseous hydrocarbon	-	As fuels, manufacture of gasoline and carbon blacks.
2.	Petroleum ether	30- 70	Solvent for fats and oils.
3.	Petrol or gasoline	70-120	Automobile fuel, dry cleaning.
4.	Benzine	120-150	Dry cleaning
5.	Kerosene	150-300	Fuel, Illuminant.
6.	Gas oil or heavy oil	300-350	Fuel for disel engine.
7.	Lubricating oil	350-400	Lubricant.
8.	Paraffin wax	Above 400	For making candles, ointments, toileteries, shoe polishes, vasaline
9.	Asphalt-black tarry residue	-	Paints, road metalling.
10.	Pitch or petroleum coke	-	Fuel, battery boxes, electrodes.

4.2.5. Octane Number

It is a measure of the anti-knock quality of a fuel. The octane number or octane rating of a given fuel may be defined as the percentage by volume of iso-octane present in the mixture and n-heptane which has the same anti – knock qualities as the fuel under consideration. The knocking depends upon the composition of the fuel. It has been identified that n-heptane knocks very badly when used as fuel. The very poor anti-knock quality has been given an octane number of Zero. Similarly 2,2,4-trimethyl pentane, called iso-octane, has the best anti-knocking properties and assigned an octane number of 100. This number is the measure of quality of fuel. 100 octane number is gasoline of planes.

4.2.6. Anti-knocking compounds

Anti-knocking compounds are reagents which are used to improve the octane number of a fuel. i.e. to reduce the knocking property of fuels.

4.2.6.1. Lead tetra ethyl

Lead tetra ethyl or Tetraethyl lead is added to petrol to minimise the knocking quality. It moderates the combustion of petrol sothat it burns smoothly. However the use of TEL is hazardous to engine due to the deposition of lead bromide. Ethyl bromide is usually mixed to avoid this. Eventually lead is converted into volatile lead bromide and escapes into air to create an airpollution (that is toxic). So presently unleaded petrol is used in automobiles.

4.3. Industrial gases

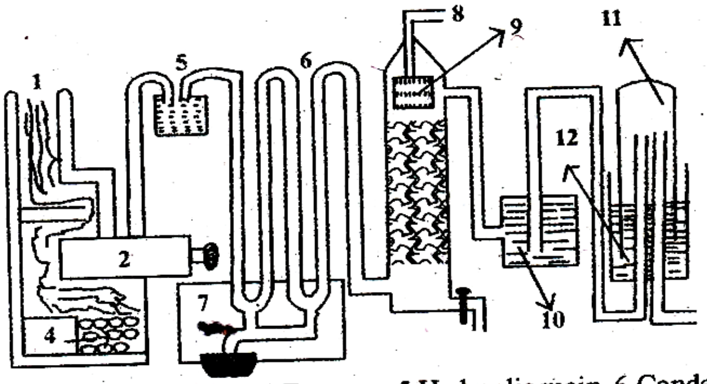
Industrial gas is a group of gases that are commercially manufactured and sold for uses in other applications. These gases are mainly used in an industrial processes. They may be both organic and inorganic, are produced by extraction from the air by a process of separation or are produced by chemical synthesis. They may be compressed gas, liquid, or solid.

Table showisng the fuels and their compositions

S.No.	Fuel	Composition
1.	Natural gas	The first six alkanes, mainly methane.
2.	Gobar gas	Methane and a little ethane.
3.	Coal gas	Hydrogen, CO and methane.
4.	Water gas	CO and H_2
5.	Producer gas	CO and N_2
6.	Liquefied petroleum gas (LPG)	Propane, propylene, n-butane, isobutane and butylene

4.3.1. Coal gas

Coal gas is a flammable gaseous fuel made from coal and supplied to the user via a piped distribution system. The coal is destructively distilled at about 100^{o}C and the volatile products are passed through water to produce Coal gas. The soluble and tarry matters are removed on the process. It contains H_2, CH_4, C_2H_4 and C_2H_2 (95%). These are combustible. However non-combustible impurities like nitrogen and CO_2 (5%) are also seen.



1.Chimney, 2. Retort, 3.Fire , 4.Furnace, 5.Hydraulic main, 6.Condensers,
7. Coal-tar and ammonical liquor, 8. Water,
9. Washing tower, 10. Purifier, 11. Gas holder, 12.Water tank

Manufacture:

The coal gas manufacturing unit is a medium size plant. The coal is heated at 1000-1100^oC in a large fire clay retorts. All the decomposed products are passed through a pipe to a hydraulic main having water.

(i) Water, Coal and Tar condense.

The gas is new passed through condensers and cooled by air.

(ii) Coal tar and turbid water with ammonia condense.

The gas is then passed through washing towers called scrubbers.

(iii) All the ammonia are washed off.

The gas is passed through purifiers (having hydrated ferric oxide).

(iv) All the impurities including residual hydrogen sulphide are absorbed.

The purified gas is collected over water in gas holders and then distributed to consumers. Its calorific value is about 500 B.Tu.U./cu.ft.

Uses:

1. Used as domestic industrial fuel.
2. Used to provide reducing atmosphere in metallurgical operations.
3. Used as illuminant.
4. Used for the melting of metals and alloys.

4.3.2. Producer gas.

Fuel gas for industrial use using producer gas technology gives **CO and N_2**. Producer gas is made by blowing air through an incandescent fuel bed (coke or coal) in a gas producer. The reaction of fuel with insufficient air for total combustion produces carbon monoxide (CO).

Manufacture

The plant used for the manufacture of producer gas is called "Gas Producer". It is a cylindrical furnace with an internal lining of fire bricks and an out mild steel casting. A blast of air is sent up from below. It is distributed through the bed of red hot coke, 'A' . Fresh coke is added from the top periodically 'D'. The hot air entering at the carbon bed "B" at the bottom of the furnace to produce CO_2.

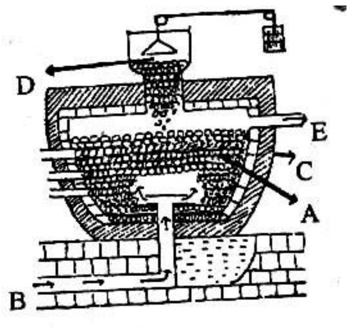
(i) $C + O_2 \longrightarrow CO_2$; $\Delta H = -97$ K.Cals. Exothermic.

This passes through the upper layer of red-hot fuel, takes more carbon and reduced to CO.

(ii) $CO_2 + C \longrightarrow 2CO$; $\Delta H = +39$ K.Cals. Endothermic.

This producer gas escapes at the outlet 'E'. It is composed of 35% CO and 65% N_2.

This is posionous, heavier than air and insoluble in water. It is a non-supporter of combustion but combustible. It has low calorific value but yet is the cheapest.



A – Red hot coke
B – Entrance for hot air.
C – Cylindrical furnace.
D - Point of fresh coke addition.
E - Producer gas exhaust.

Uses:

1. Used as a gaseous fuel for industrial purposes, automobiles, motor engines.
2. Used as an illuminant and cosmopolitan in use for it is the cheapest.

4.3.3. Water gas

Water gas is a mixture of carbon monoxide and hydrogen obtained by passing steam on red-hot coke. Second one is reversible and both occur simultaneously to result in water gas.

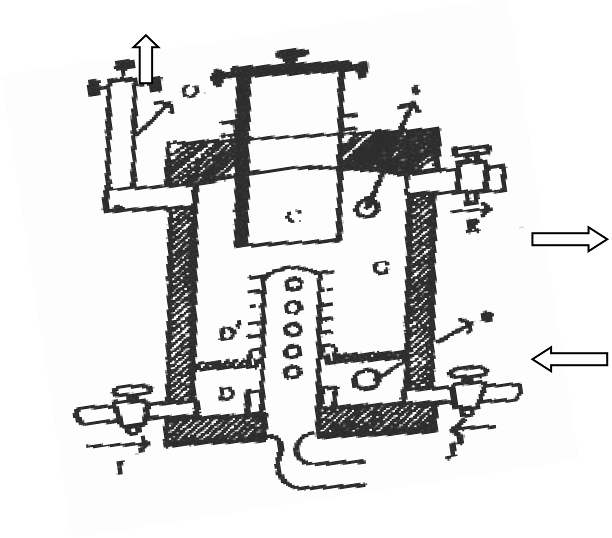
$C + H_2O \xrightarrow{\Delta} CO + H_2$; $\Delta H = +29$ K.Cals.

$C + 2H_2O \xleftrightarrow{\Delta} CO_2 + 2H_2$; $\Delta H = +19$ K.Cals.

CO : 40-50% ; H_2 : 44-50%; CO_2 : 3-7 % and N_2 = 4-5%.

Manufacture

The reaction is endothermic so coke is continually re-heated to keep the reaction going and to avoid CO_2, but form CO. The efficient working temperature is 1000-1400^oC. The coal receptacle ‘C’ is charged with coal, coke or any other suitable fuel. The air is sent from below by pipe ‘P’. Many lateral small holes provide a direct contact between the air and fuel. When run ‘S’ for the required time, water gas is collected from ‘E’. It is repeated. It’s calorific value is fairly high (280-300 B.Th.U./Cu.ft.). The flame is short and hot.



G – Generator
C – Coal receptacle(cast iron)
I - Air inlet.
I’ - Gas inlet.
S – Steam inlets.
E – Water gas outlet.
D&D’-Cleaning doors.
O – Outlet of combustion products.

Uses

1. Used for welding, and many industrial processes like methyl alcohol production etc,.
2. It is the main source of industrial hydrogen.

4.3.4. Semi water gas

Semi water gas is a mixture of water gas and producer gas. This is the product of conservative mechanism of water gas formation wherein whole heat generated can be used.

Manufacture

Combustion of carbon is an exthermic process. Some quantity of heat generated during the manufacture of producer gas will be lost in the process. But the reaction of steam and red hot carbon is an endothermic process. Therefore, if a mixture of air and steam in appropriate proportions is passed over red hot carbon, the heat generated can be used completely. The heat liberated by the combustion of carbon maintains the temperature necessary for the formation of water gas by the action of steam on carbon again and again.

Composition:

Nitrogen: 55%;CO: 30%; Hydrogen: 15%; CO_2: 10%; Methane: 2%.

Uses

1. Used as a fuel in steel industry.
2. Used for the production of power in internal combustion engines.

4.3.5. Liquefied Petroleum Gas (LPG)

Liquefied petroleum gas es are made of hydrocarbons that are gaseous at normal atmospheric pressure but may be condensed to liquids by the application of moderate pressure. LPG include mixtures of propane and butane, with some propylene, isobutane and butylenes. A powerful odorant, ethanethiol, is added so that leaks can be detected easily.

Manufacture

LPG is synthesised by refining petroleum or 'wet' natural gas; it was first produced in 1910 by Dr. Walter Snelling, and the first commercial products appeared in 1912. It currently provides about 3% of the energy consumed. It is obtained from hydrocarbons produced by refineries by applying pressure and filled in specially made cylinders.

Uses

It has all the advantages of gaseous fuels. So the advantage of using LPG are:

1. Posess high calorific value.
2. Free from residue and smoke.
3. Readily flowing gas and can be transported easily.
4. Easily lignited and complete combustion is possible.

Used as (i) domestic fuel; refrigerants; automobile fuel; public/industrial fuel utilities.

4.4. Bio-gas

Biogas typically refers to a gas produced by the biological breakdown of organic matter in the absence of oxygen. The calorific value of these bio gases range about 5300 K.Cal./cu.m.

(i) One type of biogas is produced by anaerobic digestion or fermentation of biodegradable materials such as biomass, manure or sewage, municipal waste, and energy crops. It is comprised primarily of methane and carbon dioxide.

(ii) The other principle type of biogas is wood gas which is created by gasification of wood or other biomass. This type of biogas is comprised primarily of nitrogen, hydrogen, and carbon monoxide, with trace amounts of methane.

4.4.1. Gobar gas

Of the various non-conventional energy sources, ‘Gobar gas’ has been developed and is being utilised to the maximum extent possible in our country.

It is successful because of its continuous utility and of renewable nature.

(a) Large cattle population and steady source of supply of the raw material required.

(b) Helps in reducing the deforestation as it arrests for cutting of trees for firewood.

(c) Helps in rural sanitation and in maintaining ecological balance.

(d) Lower capital cost and almost cost free maintenance.

(e) Removes drudgery of women.

4.4.1.1.Technology and composition

The organic wastes (piggery, poultry droppings etc. and agricultural wastes, kitchen wastes { water hyacinth from pond}) when subjected to decomposition without air gives rise to gas, which is rich in methane with some Carbon dioxide, Hydrogen sulphide etc.

4.4.1.2. Manufacture/Production

The production technology is very simple and user friendly. A plant consists of an (1) Inlet tank (2) digester (3)outlet tank and (4)gas distributer. The plant may of the following types:

(1) Floating drum type (Mild steel/fibre-glass/ Ferro cement digester gasholder.)

2) Fixed dome type: Janata gas plant or Deenbandhu Model.

Gobar gas is a biogas generated out of cow dung. In India, gober gas is generated at the countless number of micro plants (an estimated more than 2 million) attached to households. The gobar gas plant is basically fitted in an airtight circular pit made of concrete with a pipe connection. The manure is directed to the pit (usually directed from the cattle shed). The pit is then filled with a required quantity of water (usually waste water). The gas pipe is connected to the kitchen fire place through control valves. The flammable methane gas generated out of this is practically odorless and smokeless. The residue left after the extraction of the gas is used as biofertiliser. Owing to its simplicity in implementation and use of cheap raw materials in the villages, it is often quoted as one of the most environmentally sound energy source for the rural needs.

4.5. Industrial application

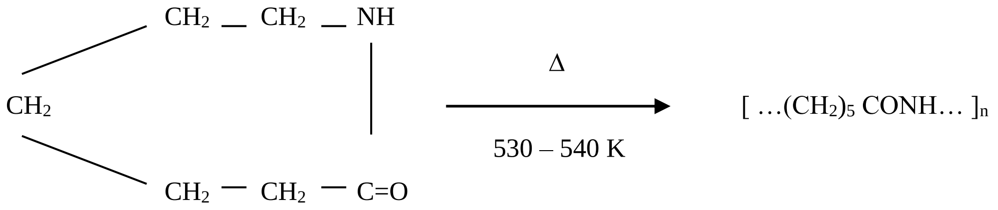
Natural fibres like cotton, wool and silk are familier to all. But there are many man-made synthetic fibres like nylon, terylene, polysters, etc.,. Due to the increase in population and modern living, the demand for these fibres have increased. Eventually these fibres are now rulling the world.

4.5.1. Nylon

Nylon is one of the most common polymers used as a fiber. It is made of repeating units linked by peptide bonds and is referred to as *polyamide* (PA). Nylon was the first successful polymer and the first synthetic fiber to be made from coal, water and air. These are formed into monomers of intermediate molecular weight, which are then reacted to form long polymer chains.

4.5.1.1.Manufacture and uses

Nylon – 6 is prepared by the condensing homopolymer formed by prolonged heating of caprolactum between 530-540K.



Used for preparing (i) ropes; (ii) fishing nets; and (iii) plastic materials.

Nylon – 6, 6 is a condensation of co-polymer formed by the reaction between adipic acid and hexamethylene tetramine.

$$HOOC\,(CH_2)_4\,COOH + H_2N\,(CH_2)_6\,NH_2 \xrightarrow{-H_2O} [\,-OC\,(CH_2)_4\,CONH\,(CH_2)_6\,NH-]_4$$

Adipic Acid Hexamethylene diamine Nylon 6, 6

Used for preparing (i) ropes and tyre cords; (ii) fishing nets; and (iii) brushes and bristles.

Terylene is a polyester. It is prepared by treating methyl terephthalate and ethylene glycol.

$$MeOCO\,(C_6H_4)\,COOMe + HO\,(CH_2)_2\,OH \xrightarrow[-Me\,OH]{H^+\text{ (or) }OH^-} [-CO\,(C_6H_4)COO(CH_2)_2O-]_n$$

Methyl terephthalate Ethylene Glycol -Me OH Terelene

Used for preparing (i) textile fibres; (ii) Magnetic tapes; and (iii) aluminised sheets.

4.5.2. Rubber

Natural rubber is an elastic hydrocarbon polymer. It is polymerized isoprene. It can also be synthesized. Synthetic rubber is a polymer which acts as an elastomer. This is made by polymerization of monomers with isoprene (2-methyl-1,3-butadiene)1,3-butadiene, chloroprene(2-chloro-1,3-butadiene), isobutylene (methylpropene) and isoprene (for cross-linking). These are mixed with specific chemicals in desirable ratio and co-polymerized for any range of physical, mechanical and chemical properties.

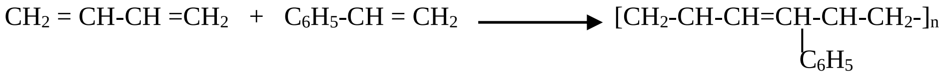
4.5.2.1.Types of synthetic rubbers

Buna-N-rubber is made by the co-polymerisation of buta diene and acrylonitrile.

$${}_nCH_2 = CH\text{-}CH = CH_2 + {}_nCH_2 = CH\text{-}CN \longrightarrow [-CH_2 – CH{=}CH\ \text{-}CH_2\ \text{-}CH_2{=}\ CH\text{-}CN\text{-}]_n$$

Used for preparing oil resistant and low temperature materials like hoses and rubber gloves.

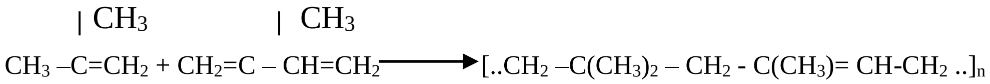
Buna-S-rubber is made by co-polymerisation of 1-3-butadiene and styrene in the ratio 1:3. They are emulsified in the presence of soap. This emulsion when heated strongly under pressure in the presence of organic peroxides as catalysts gives Buna-S-rubber.



$$CH_2 = CH\text{-}CH = CH_2 \;+\; C_6H_5\text{-}CH = CH_2 \longrightarrow [CH_2\text{-}CH\text{-}CH{=}\underset{\substack{|\\ C_6H_5}}{CH}\text{-}CH\text{-}CH_2\text{-}]_n$$

Used for preparing (i) tyres; (ii) mechanical rubber goods; and (iii) Shoe soles.

Butyl rubber is a co-polymer made from isobutylene and isoprene. The monomers are dissolved in methyl chloride and are polymerised at 80° - 100° C in the presence of anhydrous aluminium chloride as a catalyst.



$$CH_3\text{–}\overset{CH_3\\|}{C}{=}CH_2 + CH_2{=}\overset{CH_3\\|}{C}\text{–}CH{=}CH_2 \longrightarrow [..CH_2\text{–}C(CH_3)_2\text{–}CH_2\text{-}C(CH_3){=}CH\text{-}CH_2..]_n$$

Used for preparing (i)tubes for tyres;(ii) motor mounts; and(iii)vibration-damping materials.

Neoprene Rubber is prepared by treating acetylene withCu_2Cl_2 and NH_4Cl when it dimerises and gives vinyl acetylene. This is treated with HCl to give chloroprene. It undergoes free radical polymerisation (with initiators) to give neoprene.

$$\underset{\text{Acetylene}}{2CH{\equiv}CH} \xrightarrow{Cu_2Cl_2:\,NH_4Cl} \underset{\text{vinyl acetylene}}{CH_2{=}CH\text{-}C{\equiv}CH} \xrightarrow{HCl} CH_2{=}C(Cl)\text{-}CH{=}CH_2 \longrightarrow \underset{\text{Neoprene}}{[\text{-}CH2\text{-}\,C(Cl){=}CH\text{-}CH_2\text{ - }]_n}$$

Used for making (i)transmission belts;(ii) printing roller; and(iii) flexible tube materials.

4.5.3. Paints

Paint is any liquid, liquifiable, or mastic composition which after application to a substrate in a thin layer is converted to an opaque solid film.

4.5.3.1.Composition of the paint:

1. Solid pigments-(i) granular solids and dyes (titanium dioxide, red iron oxide) to contribute colour.
2. A liquid medium-linseed or other drying oil.(to bind/cohision-synthetic or natural resins - acrylics, polyurethanes, polyesters, or oils/volatiles for fluidity)
3. Solvent to adjust the viscosity (water or organic solvents such as petroleum distillate, alcohols, ketones, esters, glycol ethers).

4.5.3.2. Manufacture

Dry fine pigment is mixed with sufficient medium to convert it into the form of a stiff paste. This stiff paste is transferred to colloidal mill and converyed to a paint mixing machine and then thinned to right consistency. Some additives and drier are also added.

4.5.3.3.Kinds and uses

1. Ready-mixed paint: The commonly used oil paint in variety of colours.
2. Enamel or varnish paint: These are dry ones to make a brilliant surface that are glossy. The varnish medium is used according to the requirement.
3. Anticorrosion paints: These are red lead paints with oil base to protect steel etc,.
4. Metallic paints: Alluminium, copper-bronze and gold paints are prepared with special finely powdered metal/alloy mix in varnish for permanent brilliant colours.

4.5.4. Varnish

Varnish is a transparent, hard, protective finish or film used for glossy finish. Varnish is traditionally a combination of a drying oil, a resin, and a thinner or solvent. Varnish has little or no color, is transparent, and range from opaque to translucent.

4.5.4.1. Components, preparation and uses of varnish

(a) Oil varnishes: This is composed of

1. hard gum resins (amber, kauri gum, rosin-pine resin)
2. a dryuing oil (like linseed oil) and
3. a volatile solvent (like turpentine)

This is prepared by milling and kept in air tight containers to avoid oxidation.When applied, the volatile solvent evaporates leaving the soft oil resin film to air dry by oxidation. Best applicant to protect wood.

(b) Spirit varnishes: These are solutions of

- (i) soft resins (amber, sandarac, balsam, and others)
- (ii) volatile solvent (turpentine etc)

This is preparred by dissolution and centrifugation; kept in air tight containers. When applied, volatile solvent evaporates leaving a thin coating of resin on objects. Best applicant on both metal and wood materials.

4.5.5. Glasses

In the technical sense, glass is an inorganic amorphous product of fusion which has been cooled to a rigid condition without crystallizing with high viscosity. Many glasses contain silica and glass former. Chemically Na_2 O. CaO. $6SiO_2$ and K_2O. CaO. $6SiO_2$ glass is a fused mixture of silicates, alkali, alkaline earth compounds, glass formers (calcium oxide, magnesium oxide, tin oxide, vanadium oxide and lead oxide) and fining agents (sodium sulfate, sodium chloride or antimony oxide). It is a completely vitrified product.

4.5.5.1. Manufacture

The glass is technically manufactured in the following steps:

1. Fusion of raw materials

The fusion of raw materials vary according to the variety of glass. For ordinary soda-lime glass, the raw materials are sand, washing soda and lime stone. These are mixed in proper proportions and ground together. The resulting mass, the 'batch' is mixed with broken glass, 'cullet' and introduced into the pot or tank of the furnaces.

2. Pot furnace

In a pot furnace, pots are placed at the bottom in a circle around a central opening with hot gases and flames. The refractory roof reflects the heat on the pots. Whether the pots are open or closed, the clay rings facilitate to withdraw the molten materials.

$$Na_2CO_3 + n_1 SiO_2 \longrightarrow Na_2O.\ n_1 SiO_2 + CO_2$$

$$Na_2SO_4 + C \longrightarrow Na_2O + CO + SO_2$$

$$Na_2O + n_2 SiO_2 \longrightarrow Na_2O.\ n_2 SiO_2$$

$$CaCO_3 + n_3 SiO_2 \xrightarrow{\text{Na salts}} Na_2CO_3.\ n_3 SiO_2 + CO_2$$

The glass is a mixture of all the silicates: $Na_2O.\ n_1 SiO_2.$ $Na_2O.\ n_2 SiO_2.$ $Na_2CO_3.\ n_3 SiO_2.$

3. Shaping

The glass areticles are made by immediate blowing (moulding) molten glass into shapes

4. Annealing

These are cooled (annealed) slowly to avoid brittleness(by sudden cooling). To make the molecules arrange without strain, they are cooled step by step in cooling chambers.

5. Finishing

To make the glass articles commercially fit, they are cut, ground and polished.

4.5.5.2.Types of glasses and their uses

a. Soft glass: It is a mixture of Sodium and Calcium silicates. For glass wares and plates.

b. Hard glass: It is a mixture of Potassium and Calcium silicates. For hard glass apparatus.

c. Jena glass: It is a mixture of Zinc and Barium boro silicates. It has high alumina content and is resistant to heat, chemicals and shock. For special glass wares and instruments.

d. Optical glass: It is made by fusing red lead, potassium carbonate and sand. For spectacle

e. Glass wool: It is made by forcing molten glass through tiny holes. For thermal insulater.

f. Opal glass: It is translucent liquid glass but opalescent as glass. For transmission etc,.

4.5.6. Cement

Cement is a binder, a substance which sets and hardens independently, and can bind other materials together. The volcanic ash and pulverized additives which were added to burnt lime to obtain a hydraulic binder is the cement. Generally cement is made from limestone (for CaO), certain clay minerals (for Al_2O_3 , SiO_2, Fe_2O_3) and gypsum (for decreasing the setting time of the cement) in a high temperature to drive off carbon dioxide.

4.5.6.1.The chemical composition of cement :

1. lime (CaO)	62%
2. silica (SiO_2)	22%
3. alumina (Al_2O_3) from clay	7.5%
4. magnesia (MgO)	2.5%
5. iron oxide (Fe_2O_2)	2.5%
6. suphur trioxide (SO_3)	1.5%
7. sodium oxide (Na_2O)	1.0%
8. Potassium oxide (K_2O)	1.0%

4.5.6.2.Manufacture

1. Preparation of raw materials

Limestone of differing chemical composition from the quarries are collected and carefully blended before being crushed. It supplies $CaCO_3$ – CaO.

2. Preparation of raw meal or slurry

Red mineral(Clay) is added to the limestone at the crushing stage to provide consistent chemical composition of the raw materials. It adds Al_2O_3 , SiO_2, Fe_2O_3.

Once these materials are crushed, blended, and homogenized into stockpile.

(a) Wet process: Addition of water (40%) to make 'slurry'.

(b) Dry process: Pulverised in dry condition to make 'raw meal'.

3. Fuel planning

1,800°C heat at the flame is supplied by ground and dried petroleum coke and/or fuel oil.

4. Preparation of Cement

The raw meal is fed into the top of a preheater tower equipped with four cyclone stages. (i) As it falls, the meal is heated up by the rising hot gases and coal dust. It reaches 800°C. At this temperature, it is dehydrated and partially decarbonizes.

$$\underset{\text{Clay}}{Al_2O_3, 2SiO_2, Fe_2O_3.2H_2O} \longrightarrow \underset{\text{broken materials}}{Al_2O_3 + 2SiO_2 + Fe_2O_3 + 2H_2O \ \{+ CaCO_3\}}$$

(ii) The meal enters a sloping rotary kiln of 1,800°C flame to complete the burning process.

$$\underset{\text{Lime stone}}{CaCO_3} \longrightarrow \underset{\text{Lime}}{CaO} + CO_2\uparrow$$

(iii) The meal is heated to a temperature of at least 1,450°C. At this temperature the chemical changes required to produce cement clinker are achieved.

$$2CaO + SiO_2 \longrightarrow \underset{\text{Dicalcium silicate}}{2CaO.SiO_2}$$

$$3CaO + SiO_2 \longrightarrow \underset{\text{Tricalcium silicate}}{3CaO.SiO_2}$$

$$2CaO + Al_2O_3 \longrightarrow \underset{\text{Dicalcium aluminate}}{2CaO.Al_2O_3}$$

$$3CaO + Al_2O_3 \longrightarrow \underset{\text{Tricalcium aluminate}}{3CaO.Al_2O_3}$$

$4CaO + Al_2O_3 + Fe_2O_3 \longrightarrow 4CaO.Al_2O_3.Fe_2O_3$

Tetracalcium alumino ferrite.

5. Finish

Cement clinker is cooled and mixed with 2 to 3 % of its weight of gypsum ($CaSO_4.2H_2O$). Eventually $3CaO.Al_2O_3$ which is a fast setting constituent of the clinker reacts with gypsum to form the crystals of calcium sulpho-aluminate.

$3CaO.Al_2O_3 (CaSO_4.2H_2O) + 2H_2O \longrightarrow 3CaO.Al_2O_3. 3CaSO_4.2H_2O + 6H_2O$

Tricalcium aluminate + Gypsum Calcium suphoaluminate.

4.5.7. Ceramic

The word ceramic is derived from the Greek word κεραμικός (keramos). The term covers inorganic non metallic materials (China clay) which are formed by the action of heat. Many ceramic materials are hard, porous, and brittle.

4.5.7.1. Composition:

1. Clay : It is hydrated aluminum silicate. It is

(a) plastic;

(b) can be moulded when wet:

(c) retains the shape when dried; and

(d) when heated to high temperature, it sinters to form a hard mass in original colour.

(i) Kaolin - $Al_2O_3. 2SiO_2. 2H_2O$

(ii) Beidellite - $Al_2O_3. 2SiO_2. H_2O$

(iii) Halloysite - $Al_2O_3. 2SiO_2. 3H_2O$

2.Feldspar or spar: It is double silicate of K or Ca or Na with Al. It is

(a) fusible

(b) serves as a flux and binder.

(i) Potash feldspar – $K_2O.Al_2O_3. 6SiO_2$

(ii) Soda feldspar - $Na_2O.Al_2O_3. 6SiO_2$

(iii) Lime feldspar - $CaO.Al_2O_3. 6SiO_2$

3.Sand or flint : Sand (SiO_2) or flint is used as an opener to reduce the shrinkage of clay.

4.Fluxes : These are fusible materials. Borax, boric acid, soda ash, pearl ash (K_2CO_3), fluourspar (CaF_2), cryolite (Na_3AlF_6), iron oxide, lead oxides etc,. are fluxes.

5.Refractories : These are substances which can withstand high temperature (upto 600°C) without melting. Al_2O_3,FeO, Cr_2O_3, $MgCO_3$, TiO_2, SiC, ZrO_2 etc,. are refractories.

Ceramic Slip – for aging Shapping by potter wheel Colouring – as preferred.

4.5.7.2. Manufacture

1. **Preparation of the slip :** Clay, feldspar, sand etc. are mixed with H_2O and stirred in a revolving blunger to get a cream – like paste. This is called slip. It is then filtered through vibrating screen to remove the coarse (bits of wood, metals, coal etc,.).
2. **Filtering and aging:** The slip is passed through the filter paper to remove the water. A moist cake is obtained. It is stored in a drier for aging and to develop plasticity.
3. **Shaping of the article:** The articles are shaped by hand moulding or by potter wheel or by die pressing (Cast is made by adding Na_2CO_3 or K_2CO_3 or water glass)
4. **Firing:** The dried articles are placed in clay boxes (saggers) in the furnace(Hovel oven) to heat them without contact of the flame. During the process:
    (a) At 150 – 600°C water is totally removed.

(b) At 800 – 900^{o}C lime stone gets decomposed ($CaCO_3 \rightarrow CaO + CO_2\uparrow$).

(c) At 350 – 900^{o}C oxidation of ferrous salts and organic matters.

(d) At 1200 – 1300^{o}C silicates of metals are formed (metallic oxides + silica).

The finished article is porous and look like a biscuit and so it is called 'Biscuit'.

5. **Glazing of the 'biscuit':** To make the 'biscuit' (article) impervious to water and shiny glazes (SiO_2, Al_2O_3, Lead oxide) are applied on it. The application is done by dipping, immersion, pouring, spraying, dusting or volatilization etc,. Then it is heated up in furnace to the temperature of 700-900^{o}C to make it smooth and shiny.
6. **Colouring :** The colouring matter is either mixed in clay or sand etc,. or in the glazing compounds. They are (a)cobalt oxide (blue); (b)copper oxide/ chromium (green or red); (c) iron oxide (yellow or orange or red); (d) gold chloride (pink); (e) MnO_2 (violet); TiO_2 (pale yellow) etc,.

4.5.7.3. Uses

Used for making (i) Non-porous – china porocolain, earthwares, dolls and stone wares.

NOTES

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Unit – V :

AGRICULTURAL CHEMISTRY

5.1. Fertilizers

Plants are the producers for the world.. No organism can exist without plant producing food stuffs. Plants have nutritional requirements just like humans in order to grow, develop and complete their life cycle. The primary/basic requirements are the light, water and air and these are abundent in the appropriate ecosystem. Sixteen chemical elements are known to be important to a plant's growth and survival. These are non-mineral and mineral. The Non-Mineral Nutrients are hydrogen (H), oxygen (O), & carbon (C). These nutrients are found in the air and water. The 13 mineral nutrients, which come from the soil, are dissolved in water and absorbed through a plant's roots. There are not always enough of these nutrients in the soil for a plant to grow healthy. This is why many farmers and gardeners use fertilizers to add the nutrients to the soil. A fertilizer is a chemical product either mined or manufactured material (artificial) containing one or more essential plant nutrients that are immediately or potentially available in sufficiently good amounts.

5.1.1. Nitrogen on plant growth

- Nitrogen is a part of all living cells; it is a necessary part of all proteins, enzymes.
- Nitrogen is a part of the chlorophyll that is responsible for photosynthesis.
- It is involed in metabolic processes, synthesis and transfer of energy.
- Nitrogen help plants with rapid growth, seed and fruit production.
- It aids in improving the quality and pigmentation of leaf and forage crops.
- Plants can take up N in-NH4 Ammonium, NO3 Nitrate, Organic and molecular N.
- Nitrogen often comes from fertilizer application and from the air(legumes from air).

5.1.2.Phosphorous on Plant growth

- Phosphorus (P) is an essential part of all tissues of the plant.
- Effects rapid growth, flowering, seed formation and root growth.
- Involved in the formation of all oils, sugars, starches, proteins etc.
- Fertilizer (superphosphate/phosphoric acid) also helps acidify alkaline water.

- It is an essential in the process of photosynthesis, respiration and metabolism.
- It stimulates proper plant maturation withstanding stress (winter, summer etc.,).
- Phosphorus comes from fertilizer, bone meal, superphosphate and also from soil.

5.1.3.Potassium on Plant growth

- Potassium is absorbed by plants in larger amounts than all others (except nitrogen).
- It is essential for the absorption of anions (NO_3^- , $H_2PO_4^-$ and HPO_4^{2-}) in saps.
- It is essential for the transformation of NO_3^- to NH_2^- .
- Presently most growers supply K in the form of potassium nitrate (KNO3).
- Potassium is also supplied to plants as organic materials and complex fertilizer.
- Helps in building of protein, photosynthesis, fruit quality and reduction of diseases.

5.1.4. Urea

Urea is a nitrogen-containing chemical used as a fertilizer. It is more friendly to the soil than nitrates and ammonium salts (the residual nitrates/sulphates make the soil acidic). Urea is converted to ammonium ion form {$(NH_4)_2 CO_3$} in the soil. It is well retained in the soil and does not leave any residue (converted to-NO_3 and CO_3). It has 45% of nitrogen and highly soluble in water. It is absolutely used by plants.

5.1.4.1. Commercial production of Urea

Urea is produced commercially from two raw materials, ammonia and carbon dioxide. Large quantities of carbon dioxide are produced during the manufacture of ammonia from coal/ hydrocarbons/ petroleum etc,. This allows direct synthesis of urea from these raw materials. The production of urea from ammonia and carbon dioxide takes place in an equilibrium reaction, with incomplete conversion of the reactants. Unconverted reactants can be recycled for complete conversion to urea in a total-recycle process.

The reactants (CO_2 : NH_3 = 1:3 or 4) are passed into the reactor and in the pressure of 378 atmosphere. The temperature is partially maintained by the heat of reaction at 200^o to 210^{o}C. External heat is also supplied. After several hours 8% Urea is produced and the recycling process helps for the complete conversion. It is usually converted into globules by spraying from the top of a tower and heated by hot air.

$$\begin{array}{c}2NH_3\\+\\+\\CO_2\end{array} \longleftrightarrow NH_2\,COONH_4 \longleftrightarrow \begin{array}{c}NH_2\,CONH_2\\ \\ \\H_2O\end{array}$$

5.1.5. Commercial production of Triple superphosphate

Triple Superphosphate is a high analysis product of the reaction between phosphate rock and phosphoric acid, containing 45 - 50% available phosphate. It consists of almost pure $Ca(H2PO4)2$ with very little gypsum.

In the "slurry" granulation process, the ground phosphate rock is reacted with relatively weak phosphoric acid (32-40% $H3PO4$). The resulting slurry is mixed with a large quantity of dried, recycled fine granules which are coated with the slurry, thus producing the desired granule size. The coated granules are dried and screened and the product size material is withdrawn to storage, the remainder being recycled to the process.

5.1.6. Complex and mixed fertilizers

In general, most plants grow by absorbing nutrients from the soil. Their ability to do this depends on the nature of the soil. Depending on its location, a soil contains some combination of sand, silt, clay, and organic matter.

5.1.6.1.Complex fertilizers, composition and manufacture.

Complex fertilizers supply more than one plant nutrient.

Example: Di-Ammonium Phosphate (DAP) contains 18% N and 20% P (46% P_2O_5). Similarly commercially available NPK 17-17-17, 14-28-14 are standards. Here an ammonia solution, triple phosphate, potash are mixed with organic matter and systematically granulated in a uniform manner for the plant use. Here nitrogen as nitrates, phospherous as phosphates and potassium as potassium sulphates are made available.

Use of complex fertilizers

The disadvantage with complex fertilizers is that the ratios of the nutrients are fixed and the farmers have to supplement with straight fertilizers to meet the crop requirements. However

- The possibility of adulteration is generally less.
- Each granule is homogenous in nutrient content.
- Being granular, the drilling of fertilizer is easy.
- They are cheaper than straight or mixed fertilizers.

- Phosphorus availability is not affected as it contacts less soil particles.

5.1.6.2. Mixed Fertilizers, composition and manufacture

Mixed fertilizers are physical mixture of two or more straight and/or complex fertilizers to supply particular combination of nutrients.

Example: DAP and Muriate of Potash may be mixed in correct proportion/ratio to get a fertilizer mixture of grade 12-32-16 of N, P_2O_5, and K_2O. However in addition to the approperiate mixing, they should have a good physical conditions. It should be drillable in the transport, purchase, storage, distribution etc,.

- There will be considerable saving in time and labor in application to the crops, as all the nutrients required are present in the same packing.
- One can ensure balanced nutrient application if suitable mixture is chosen.
- Micronutrients can also be included in the mixtures.

Limitations of the mixed fertilizers

There is possibility for adulteration with inert material. Farmers themselves can mix the fertilizers provided they are knowledgeable.

5.1.7.The mineral nutrients : macronutrients and micronutrients

Macronutrients can be broken into two more groups:

5.1.7.1. (i) **The primary nutrients**: Nitrogen (N), phosphorus (P), and potassium (K). These major nutrients and plants use large amounts for their growth and survival.

5.1.7.2. (ii**) The secondary nutrients**: Calcium (Ca), magnesium (Mg), and sulfur (S). There are usually found enough in the soil. However Ca and Mg are added with lime to the acidic soils; sulfur is usually formed from the slow decomposition of organic matter etc,.

Sulphur(S)

Sulphur forms part of two important amino acids which are part of the many building blocks of protein. Sulphur is essential to form B1 vitamin, many enzymes and cold resistant power.

Calcium(Ca)

Calcium is essential for plant growth, cell division and enlargement. It is a component of cell membranes and is important for developing the root system, shoot tips and storage organs. Calcium aids in pollen development and to retain their foliage.

Magnesium(Mg)

Magnesium occurs in chlorophyll and is also an activator of enzymes.

5.1.7.3. Micronutrients are those elements essential for plant growth in very small (micro) quantities. The micronutrients are boron (B), copper (Cu), iron (Fe), chloride (Cl), manganese (Mn), molybdenum (Mo) and zinc (Zn). Recycling organic matter gives all these

Iron(Fe)

Iron gives green color to foliage for it is required for chlorophyll synthesis. It is part of the make up of enzymes; aids in protein synthesis, photosynthesis and metabolicfunctions.

Zinc(Zn)

Zinc is a part of the make up of enzymes. It increases the metabolic rate and cell functions.

Manganese(Mn)

Manganese is part of the make up of enzymes; aids in photosynthesis and metabolism. **Copper(Cu)**

Copper as amine oxidase enzyme (CuAO) produces of H_2O_2 in plant cell walls during cell development and in response to pathogen attack. It is a catalyst in photosynthesis and respiration. It is a part of enzymes in protein synthesis. It is important in carbohydrate and protein metabolism; lining of cell walls; for flavor, storage and sugar content of fruits.

Molybdenum(Mo)

Molybdenum is part of the make up of enzymes. It aids symbiotic nitrogen fixation.

Boron(B)

Assist in the metabolic function of plant and aids in cell division. **Cobalt(Co)**

Cobalt inhibits ethylene; aids shoot development; helps in chlorophyll and protein synthesis.

5.2. Manures

Organic material that is used to fertilize land, usually consisting of the wastes from livestock, with litter such as straw, hay, or bedding. This consists of most of the nitrogen, phosphorus, and potassium and it is an enormous fertility resource. Green manures are cover crop of some kind, such as rye, that is plowed under while green to add fertility.

As manure must be managed carefully in order to derive the most benefit from it, some farmers may be unwilling to expend the necessary time and effort. Manure must be carefully stored to minimize loss of nutrients, particularly nitrogen. It must be applied to the right kind of crop at the proper time. Most of the modern farming do not take effort to lay them leading to the discard of these materials without reuse. Such acts lead to the pollution and environmental hazards.

5.2.1. Bulky organic manure

Among sources of organic matter and plant nutrients, farm manure/bulky organic manure has been of major importance in past years. Manure is understood to mean the refuse from stables and barnyards, including both excreta and straw or other bedding material, while the term fertilizer refers to chemicals.

The main benefits of bulky organic manure are indirect. It supplies humus, which improves its capacity to absorb and store water, by enhancement of aeration, and by favouring the activities of lower organisms.

- Manure incorporated into the top soil will help to prevent erosion from heavy rain.
- It slows down evaporation of water from the surface.
- It is a source of essential plant nutrients and also a soil protector.

5.2.2. Farm yard manure

Livestock produces large amounts of manure; it has value in maintaining and improving soil because of the plant nutrients, humus, and organic substances contained in it. Farm yard manure/livestock produces usually consists of the feces and urine of domestic livestock, with or without accompanying litter such as straw, hay, or bedding. Farm animals void most of the nitrogen, phosphorus, and potassium that is present in the food they eat, and this constitutes an enormous fertility resource. A ton of manure from cattle, hogs, or horses contains nitrogen: phosphorus pentoxide : potash = 10 : 5 : 10 pounds.

The complex chemical changes occur in the food at the digestive tract of the cattle by the enzymes and microbes increases the ‘biorich nature’ of the soil. The different levels of decomposition of different materials enrich the soil. These are

1. carbohydrates including cellulose are half decomposed;
2. proteins are broken down for easy nitrogenation;
3. many elements such as Potassium are eliminated in the urine; and
4. most of phosphorous that are eliminated without absorption.

5.2.3. Handling and storage

The manures were piled up and spread at leisure in olden days. The present condition of confined and concentrated animal management has changed manure handling and storage. Though some loss of nitrogen and organic matter may occur in modern methods, most of the other nutrients are well preserved from evoporation and decipation. The following methods are being used to handle farm manures.

1. Collection and spreading of the fresh manures daily.
2. Storage and packing in piles to ferment before spreading.
3. Aerobic liquid storage and treatment of the manure prior to application.
4. Anaerobic liquid storage and treatment prior to application.

5.2.4. Manures of plant origin

5.2.4.1.Oil cakes.

Non edible oil cakes - castor-cake, cotton seed cake, mahua cake, karanj cake.Edible oil cakes - coconut cake, linseed cake, sunflower cake, groundnut cake. Cottonseed meal is a by-product of cotton manufacturing. As a fertilizer, it produces a somewhat acidic reaction; consequently, it is frequently used for fertilizing acid-loving plants such as azaleas, camellias, and rhododendrons. Formulas vary slightly, but generally, cottonseed meal contains 7 percent nitrogen, 3 percent phosphorus, and 2 percent potash. Nutrients are most readily available to plants in warm soils, but there is little danger of burn.

5.2.5. Manures of animal origin

5.2.5.1. (A) Blood meal (dried).

Blood meal is dried, powdered blood collected from cattle slaughterhouses. It is a rich source of nitrogen, so rich, in fact, that it may burn plants if used in excess. Gardeners must be careful not to exceed the recommended amount suggested on the label. In addition to nitrogen, blood meal supplies some essential trace elements, including iron.

5.2.5.2.(B) Fish meal

Fish emulsion, a balanced, organic fertilizer, is a partially decomposed blend of finely pulverized fish. A strong odour is associated with most brands of fish emulsion fertilizer, but the smell dissipates within a day or two. Recently, deodorized brands have been developed. Fish emulsion is high in nitrogen and is a source of several trace elements. Contrary to popular belief, too strong a solution can burn plants, particularly those growing in containers. In the late spring, when garden plants have sprouted, an application of fish emulsion followed by a deep watering will boost the plants' early growth spurt.

5.3. Pesticide

A pesticide is a substance or mixture of substances{chemical substance, biological agent (a virus or bacteria), antimicrobial, disinfectant} used for preventing, controlling, repelling, mitigating or lessening the damage caused by a pest. Pests include insects, plant pathogens, weeds, mollusks, birds, mammals, fish, nematodes (roundworms) and microbes that compete with humans for food, destroy property. They are often vectors for disease or cause a nuisance. Although there are benefits to the use of pesticides, there are also drawbacks, such as potential toxicity to humans and other animals.

5.3.1. Pesticides are of five main types:

1. insecticides (to kill insects) – DDT, BHC, Pyrethrins.
2. fungicides (to kill fungal diseases) – Copper oxychloride.
3. herbicides (to kill weeds) - alachlor2,4,-D compounds.
4. Acaricides (to kill ticks and mites) – malathion.
5. Rodenticides (to kill rodents like rats, mice etc,.) – Zinc phosphide.

5.3.2. An insecticide is a pesticide used against insects in all developmental forms. Insecticides are used in agriculture, medicine, industry and the household. Insecticides have the potential to alter ecosystems; many are toxic to humans; and others are concentrated in food chain.

5.3.2.1. The classification of insecticides is done in several different ways:

Mode of action – The mode of action is the action on the pests (how it kills or inactivates). It is important in predicting toxicity to unrelated species such as fish, birds and mammals.

1. **Systemic** insecticides are absorbed by treated plants. Insects ingest them while feeding and die. E.g.: Carbofuron, Furadon etc on sucking pests of cotton etc.,.
2. **Contact** insecticides are neural toxic to insects on direct contact. E.g.: DDT, Pyrethrin etc on Mosquitoes and others.
3. **Stomach** poisons are applied on the surface of plants, fabrics or added to baits. It is eaten by pests and get killed. E.g.: Nicotine preparations on ants, caterpillars.
4. **Fumigants** are used on insect pests that are hard to reach. Sprays enter them and kill (breathe or exposed). E.g.: HCN on cockroaches, beetle(in bins), grub(on roots).
5. **Repellents** are chemicals that repel the pests from the environment. E.g. Dimethyl and dibutyl phthalates on most of the domestic pests.

6. **Desiccants** are chemicals that kill the pests by the dehydration. E.g.Calcium phosphate, activated clay on soft bodied Aphids and Bedbugs.
7. **Sterilants** are substances that do not kill the pests but prevent it from reproducing. These are species specific and selective.

Mode of origin (chmical nature)

Natural insecticides, such as nicotine and pyrethrum, are made by plants as defences against insects. These are used against insect pests on many agricultural crops.

Inorganic insecticides are manufactured with metals and include arsenates copper- and fluorine compounds, which are now banned. However sulfur is commonly used.

Organic insecticides are synthetic chemicals that comprise the largest numbers of pesticides used today. (i) Chlorinated hydrocarbons (DDT); (ii) Organophosphorus (parathion) (iii) Carbamates (carbaryl); and (iv) Others (thanite)

5.3.3. General methods of application

Pesticides are required in small concentration to act against pests for any situation. So it is necessary to provide details of effective application. These are usually applied in the form of dusts, emulsions, solutions, wettable powders, aerosols and granules.

1. Dusts: Dusts are usually made by diluting the toxicant with finely ground plant materials (wheat or walnut shell flours or with minerals like talc, clays and sulphur).
2. Emulsions: An emulsion is a liquid (toxicant) dispersed in another liquid (organic solvent) wherein each maintain their identity. Further these are diluted with water to facilitate spray applications.
3. Solutions: These are molecular mixtures of toxicant in a solvent like water/organic liquid (kerosene). These are applied by spraying, dripping or dust base brushing.
4. Wettable powders: These are toxicants adsorbed or absorbed on powders that can be readily mixed with water to make them wet or active against pests. These form suspension type sprays(to be agitated before use to get uniform application.
5. Aerosols: These are suspensions of solid or liquid of ultramicroscopic size. It facilitates suspended nature for a long time to act on pests. These are liquefied gas applied by propelling agents mechanically to generate oil clouds or fogging.

6. Granules: These are toxicants mixed with talc or clays designed to be applied in soil to act on several insect pests directly or through plant systems for a long time. Usually low percentages of systemic insecticides and fungicides are combined.

5.3.4. Toxicity:

Pesticides are designed to control pests, but they can also be toxic to desirable plants and animals, including humans. Since even fairly safe pesticides can irritate the skin, eyes, nose, or mouth, it is essential to understand how pesticides can be toxic and how to reduce or eliminate the exposure to them. Pesticides can enter the body orally (through the mouth and digestive system); dermally (through the skin) or by inhalation (through the nose and respiratory system).

Oral exposure

Oral exposure may occur by accident, carelessness, smoking or eating without washing after using a pesticide, splashing concentrate while mixing or eating food stuff with recent pesticide spray. The oral toxicity depends on the material and the amount swallowed.

Dermal exposure

Dermal (skin) exposure accounts for about 90% of problems. It may occur any time (when mixed, applied or handled). Dry/wet or liquids, pesticides can be absorbed through the skin.

These are expressed as “oral” and “dermal” toxicity in terms of LD_{50} values. The median lethal dose, **LD_{50}**, is the dose in mg/Kg (milligram of poison per kilogram of body weight) which would kill one half of an unlimited population of the species.

Hazards

Hazard is a function of the toxicity of a pesticide and the potential for exposure to it.

1. Direct toxic effects.
2. Ecological imbalance leading to the blooming of certain pests causing high damage.
3. Environmental pollution leading to deterioration of food, water, soil and air quality.
4. Development of pest resistance to pesticides, eventuality being dangerous/alarming.

Types of poisons and their effects: It is usually divided into two types, acute or chronic.

Acute toxicity is due to short-term exposure and happens within a short period of time; Chronic exposure is due to repeated/long-term exposure and happens over a longer period.

Type	Number of Exposures	Time for symptoms to develop	Examples
Acute	usually 1	immediate (minutes to hours)	Organophosphorus etc,.
Chronic	more than a few	one week to years	Organo chlorines etc,.

5.3.5. Safety measures

1. To reduce risks of pesticides is to use non-chemical control methods in pest control.
2. Safty measures include removing sources of food and water (such as leaky pipes).
3. Strict practice of the directions of label, including all precautions and restrictions.
4. Destroying pest shelters and breeding sites (such as litter and plant debris).
5. Avoiding drifting/draining the pesticide into garden, pool or environment.
6. Avoiding the use of products, for pests that are not indicated on the label.
7. Changing clothes and washing the hands/body after applying pesticides.
8. Removing the children, their toys, and pets before applying a pesticide.
9. Using protective measures – protective clothing and equipments.
10. Removing or covering the food during indoor applications.
11. Not to spray pesticide outdoors on windy or rainy days.
12. Not using more pesticide than directed by the label.
13. Avoid buying more pesticides than the need.
14. Stict practice of regulations regarding disposal of waste/excess pesticide.

5.3.6. An insecticide is a pesticide used against insects in all developmental forms. Insecticides are used in agriculture, medicine, industry and the household. Insecticides have the potential to alter ecosystems; many are toxic to humans; and others are concentrated in food chain.

5.3.7. Plant products

5.3.7.1. Nicotine

Nicotine is an alkaloid ($C_{10}H_{14}N_2$) found in the nightshade family of plants (*Solanaceae*), predominantly in tobacco and coca, and in lower quantities in tomato, potato and green pepper. Nicotine constitute approximately 0.6 - 3.0% of dry weight of tobacco. It functions as an antiherbivore chemical, being a potent neurotoxin with particular specificity to insects. Nicotine is a hygroscopic, oily liquid that is miscible with water. Nicotine easily penetrates the skin. Therefore nicotine was widely used as an insecticide.

They are prepared commercially from the waste of tiobacco by steam distillation in the presence of an alkali. It is a non-persistent contact poison. It is toxic not only to insects butalso to higher animals. It is the best fumigated non-persistant contact poison to eliminate pests in green house.

5.3.7.2. Pyrethrin

Pyrethrum was cultivated as ornamentals for their showy flower heads. It is also the name of a natural insecticide made from the dried flower heads of *C. cinerariifolium* and *C. coccineum.*. They are perennial plants with a daisy-like appearance and white petals. The plant is economically important as a natural source of insecticide.

The flowers are pulverized and the active components called pyrethrins, contained in the seed cases, are extracted and sold in the form of an oleoresin. This is applied as a suspension in water or oil, or as a powder. Pyrethrins attack the nervous systems of all insects. When not present in amounts fatal to insects, they still appear to have an insect repellent effect. Piperonyl butoxide mixing gives synergic effect enabling high residuality and good knockdown. They are less toxic to mammals and birds. They are non-persistent, being biodegradable and photosensitive. They are considered to be the safest insecticides for use around food.

5.3.8. Inorganic pesticides

Inorganic insecticides are manufactured with metals and include arsenates copper- and fluorine compounds, which are now banned. However sulfur is commonly used.

5.3.8.1. Borates

Borates are chemical compounds containing boron bonded to three oxygen atoms. It forms salts with metallic elements. Boron found in nature is commonly called as a borate mineral. Boron is also found combined with silicate to form complex borosilicate minerals. Borate exists in many forms.

Preparations and mode of action

It is normally in acidic condition - boric acid. Boric acid does not dissociate in aqueous solution, but is acidic due to its interaction with water molecules and tetrahydroxyborate is formed. It ($B(OH)_3 + H_2O \rightleftharpoons B(OH)_4^- + H^+$) is a stomach poison for cockroaches. Common borate salts include sodium metaborate, $NaBO_2$, and sodium tetraborate, $Na_2B_4O_7$. The latter also occurs naturally as the hydrous mineral borax, $Na_2B_4O_7 \cdot 10H_2O$. It is useful in the control of maggot in manure pits and maggots in the wounds of animals. Though they do not breakdown, they are not hazardous for they are non-poisonous and non-corrosive.

5.3.9. Organic insecticides

These are synthetic chemicals that comprise the largest numbers of pesticides used today.

5.3.9.1. DDT

DDT (Dichloro-Diphenyl-Trichloroethane) was first synthesized in 1874; till World War II, DDT was used with great effect to control mosquitoes and other insects spreading diseases. The Swiss chemist Paul Hermann Müller of Geigy Pharmaceutical was awarded the Nobel Prize in Physiology or Medicine in 1948 "for his discovery of the high efficiency of DDT as a contact poison against several arthropods."

Preparations and mode of action

DDT is an organochlorine insecticide. It is a highly hydrophobic, colorless, crystalline solid with a weak, chemical odor. It is nearly insoluble in water but has a good solubility in most organic solvents, fats and oils. DDT is produced by the reaction of chloral (CCl_3CHO) with chlorobenzene (C_6H_5Cl) in the presence of a sulfuric acid catalyst. The major product of this reaction is the p,p isomer, but the o,p isomer is also generated in significant amounts. DDT is moderately toxic, with a rat LD50 of 113 mg/kg and has potent insecticidal properties; it kills by opening sodium ion channels in insect neurons, causing the neuron to fire spontaneously. This leads to spasms and eventual death. Insects with certain mutations in their sodium channel gene may be resistant to DDT.

5.3.9.2. BHC

Lindane, also known as gamma-hexachlorocyclohexane and benzene hexachloride, is an organochlorine insecticide was dicovered by Faraday in 1825. The insecticidal properties of Lindane was evaluated only in 1942. BHC has been used as in insecticide in agriculture and as a treatment for headlice and scabies.

Preparations and mode of action

BHC is obtained as an addition product when benzene is treated with chlorine in the presence of sunlight. It is an amorphous buff coloured substance with a characteristic musy odour. It is insoluble in water, but soluble in benzene and kerosene. It is stable towards light, air and heat and acids, but decomposes with alkalies. The major one is BHC (65% with least toxicity) and other 15 isomers present. Of these gamma isomer is an insecticide called Lindane or Gammexane which is about 1,000 times more powerfull. It has an oral LD50 of 88 mg/kg in rats and a dermal LD50 of 1000 mg/kg. If consumed by humans, lindane primarily affects the nervous system, liver and kidneys, and may be a carcinogen and/or endocrine disruptor.

5.4. Fungicides and Herbicides.

5.4.1. Fungicide

Fungicides are chemical compounds used to prevent the spread of fungi in gardens and crops, which can cause serious damage resulting in loss of yield and thus profit. Fungicides are also used to fight fungal infections. Fungicides can either be contact or systemic. A contact fungicide kills fungi when sprayed on its surface; a systemic fungicide has to be absorbed by the plant.

5.4.1.1.Sulphur compounds

Sulphur is the most common active fungicide (acaricide also). It is 0.08% to 0.5% concentrate according to the potent fungicide requirements. In powdered form, the concentration is usually around 90%, and is very toxic.

Lime sulphur is the aqueous solution of calcium polysulphides. It is prepared by sulphur solution in calcium hydroxide suspensions preferably under pressure in the absence of air. Calcium tetrasulphide and calcium pentasulphide are the major consitituents in the mixture and their fungicidal activity is the best.

5.4.1.2. Copper compounds

Copper compounds have their most extensive employment in agriculture. In 1761 it was discovered that seed grains soaked in a weak solution of copper sulphate inhibited seed-borne fungi. Cuprous oxide is commonly used as a pigment and as a fungicide. Copper oxychloride is another important fungicide to act on the leaf fungal diseases of potato, tomato, tea and coffee.

5.4.1.3. Bordeaux mixture

In 1807 the steeping of cereal seeds in a copper sulphate solution for a limited time and then drying them with hydrated lime became the standard farming practice for controlling stinking smut or bunt of wheat (the fungi) at

Bordeaux region of France. It is then developed as a commercial fungicide. Bordeaux mixture is prepared by copper sulphate (5 pounds of fresh hydrated lime paste) mixed together and stirred well. It was used to control garden, vineyard, nursery and farm infestations. It is used at higher dilutions to control fungi in fruit.

Organic copper compounds

Recently many experiments have been done with several organic copper fungicides. Copper oxinate is the copper salt of oxine (8-hydroxy quinoline). It has been used as a wettable powder for the control of many diseases of plants (apple and pear scap; many soft fruit fungal diseases; many fungal infestations of vegitables and flowers).

5.4.2. Herbicides

Weed control is the botanical component of pest control, stopping weeds from reaching a mature stage of growth when they could be harmful to cultivated plants and livestock. The most basic weed control method is ploughing which cuts the roots of annual weeds. Today, chemical weed killers known as herbicides are widely used. A **herbicide** used to kill unwanted plants is 2,4 –D-Chlorinated phenoxy acetic acid. Selective herbicides kill specific targets while leaving the desired crop (triazines, phenyl urea). These herbicides interfere with the growth of the weed often based on plant hormones(aliphatic acids). Some plants produce natural herbicides, such as the genus *Juglans* (walnuts). They are applied in total vegetation control (TVC) programs for maintenance of highways and railroads. Smaller quantities are used in forestry, pasture systems and management of areas set aside as wildlife habitat. Herbicides can be clssified by activity, use, chemical family, mode of action or type of vegetation controlled.

By activity:

- **Contact herbicides** destroy only the plant tissue in contact with the chemical. These are the fastest acting herbicides. They are less effective on perennial plants.
- **Systemic herbicides** are translocated through the plant (either foliar application or soil application). They control perennial plants, but slow in action.

By use:

- **Soil-applied herbicides** are applied to the soil and taken by the roots of target plant.
- **Pre-plant herbicides** are soil applied prior to planting; mechanically incorporated.

- **Pre-emergent herbicides** are applied to the soil before the crop emerges and prevent germination or early growth of weed seeds.
- **Post-emergent herbicides** are applied after the crop has emerged.

By chemical nature:

Organic herbicide

- **Synthetic auxin** inaugurated the era of organic herbicides. They were discovered in the 1940s after the study of plant growth regulator auxin. Synthetic auxins mimic this plant hormone. They have many points of action on cell membrane; are effective in controlling selected dicot plants. 2,4-D Chlorinated phenoxy acetic acid is a synthetic auxin herbicide.
- **Photosystem II inhibitors (Nitro compounds)** reduce electron flow from water to $NADPH_2^+$ at the photochemical step in photosynthesis. They prevent quinone from binding to this site. Therefore, electrons accumulate on chlorophyll molecules. As a consequence, excess oxidation reactions lead the plants to die. The triazine herbicides (including atrazine) and urea derivatives (diuron) are nitro compounds.

Inorganic herbicide

- **Arsenic compounds**: An notable one would be the arsenical class of herbicides. It is non-selective. It is a solid as an aqueous solution containing arsenious oxide (As_2O_3) in water or as dry granules. It is used in rubber plantation. Sodium arsenite is also used for potato haulm destruction.
- **Boron compounds**: Borax and crude sodium borates are common non-selective herbicide. They are not soluble in water and also non-poisonous and non-corrosive.
- **Cynamide cyanides and thiosyanates:** Calcium cyanamide is water soluble; it is used as a powder or granules in soil. It is the best weed control chemical in tobacco field and pre-emergence weedicide in corn and horticultural crops. Lauryl thiocyanate is toxic to many fly pests and all weeds.
- **Chlorates**: Sodium chlorate is non-selective and used as pre-plant herbicide. However its toxicity and hazards are reduced by the addition of calcium chloride.
- **Sulphamates**: Ammonium sulphamate is a woody plant killer. It is sprayed or used as a wetting agent. It is used against stumps, aged unwanted woody plants.

5.4.3. Acaricides

Miticides or acaricides are pesticides that kill mites. Antibiotic miticides, carbamate miticides, formamidine miticides, mite growth regulators, organochlorine and organophosphate miticides are all in this category.

- Diatomaceous earth kills mites by cutting through the skin which drys out the mite.
- Ivermectin can be prescribed by a medical doctors to rid humans of mite and lice infestations. They also serve in agricultural formulations for birds and rodents.
- Methoprene is virtually harmless to other non-insects and higher ones show tolerance. It is used for the indoor as weeing spray only. It breaks down in sunlight.
- Hydroprene is toxic to fish and birds. It is for indoor use only, as it breaks down in sunlight. Hydroprene is used as an aerosol space spray.
- Fenson is the 4-chlorophenyl benzene sulphonate, and it is used for the control of red spiders, essentially all spider eggs. It is used against the mites on beans and cotton in 5% concentration spray.
- Azobenzene is an organic compound which evoporates readily when heated. It is used to control red spiders in green houses.

5.4.4. Rodenticides

Rodenticides are a category of pest control chemicals intended to kill rodents. Single feed baits are chemicals sufficiently dangerous that the first dose is sufficient to kill. An effective rodenticide must be tasteless, odorless and delayed effect at lethal concentrations.

- Anticoagulants are defined as chronic (death after 1 - 2 weeks post ingestion), second generation, single/multiple dose of the vitamin K cycle, resulting in inability to produce essential blood-clotting factors (prothrombin or related factors).
- Metal phosphides(Zinc phosphide) have been used as single-dose fast acting rodenticides (death within 3 days) along with food for the rodents to eat. The acid in the digestive system reacts with the phosphide to generate the toxic phosphine gas.
- Baruyn carbonate $BaCO_3$, causes haemorrhage of gastro-intestinal tract and kidneys along with muscular paralysis for rodents. It is classical fast acting rodenticide but rarely used for it is toxic to most of the other animals and Man even in small doses.

5.4.5. Chemical Attractants

Many chemical and visual lures attract insects and can be used to monitor or directly reduce insect populations. Because these attractants are used in ways that do not injure other animals or humans or result in residues on foods or feeds, they can be used in an environmentally sound pest management programs.

The effective use of attractants and traps requires knowledge of basic biological principles and pest/crop-specific details involved in applications. Insects use many ("semeio" = sign.) semiochemicals to convey messages between them. Their receptor systems screen out all irrelevant chemical messages and detect messengers of low concentrations. These are volatile compounds (Pheramones) and environmental impact chemicals (ferment odour).

Pheramones

- (i) to attract a mate (sex pheromones);
- (ii) to signal alarm in honey bees, ants, and aphids(alarm pheramone).
- (iii) to call others to a suitable food or nesting site (aggregation pheromones);
- (iv) to regulate caste/reproductive development in social insects (honeybee/termite).

Environmental chemical impacts

- (i) Fruit fermenting smell (to attract butter flies and flies)
- (ii) Sweat and respiratory waste (CO_2) of man with blood smell (attract mosquitoes)

1. 10 acetomy-cis-7-hexadecenol is the synthetic mimic of sex pheramone of Gypsy moth that is used to attract males to the trap.
2. 10-octo-keto- dextro-ethainine is the synthetic mimic of aggregation (for food / nest formation) pheramone of Black ant used to trap male moths.
3. A mixture of geraniol and eugenol (1:1) serve as food lure and attract adult beetle.
4. Fermenting syrups and sugars attract moths and butterflies to trap.
5. Isoamyl salicylate attracts hornworm moths (tomato and tobacco pest) to aggregate.

5.4.6. Repellants

Repellants are the chemical substances causing insects to move away from the source and have been defined as “substances whose stimuli” elicit avoiding reaction. These are applied to skin, clothing or other surfaces which discourages insects (and arthropods) from landing or climbing on that surface. They help prevent pests serving as vectors for diseases.

T he mode of action is the negative response of insects due to the physical and chemical properties of these chemicals. They cause directed movement away from the applied area or negative behavioral response stimulated through chemoreceptors.

Common insect repellents

N,N-diethyl-m-toluamide – against mosquito and other flies.

Essential oil of the lemon, eucalyptus and its active ingredient p-menthane-3,8-diol (PMD)

Icaridin repel most of the bugs and flies.

Citronella oil, Soybean oil and Neem oil are repellents for the adult flies and beetles.

They are actually insecticide for most of the larval stages of the pests and parasites.

Permethrin is different in that it is actually a contact insecticide.

Trichlorobenzene does avoid or eliminates termites from the environment.

5.4.7.Preservation of seeds.

The purpose of seed preservation is to maintain the seed in good physical and physiological condition from the time they are harvested until the time they are planted. Such methods may be classified into Physical and chemical methods.

Physical methods:

1. Cleanliness

The seeds are to be cleaned off the trash for it may harbour insect pests or fungi. The free circulation of air is well maintained in a clean group of seeds.

2. Dry condition

The seeds must be properly dried. High or low moisture in the seeds may accelerate or retard the growth factor leading to their own destruction at the preserved site. The store house should have ventilation and aeration at the equilibrium.

3. Store house

The construction of store house and storage should be planned (i) to shelter from the rain; (ii) not to gain moisture; (iii) not to get heated up; and to have controlled aeration.

4.Prevention of birds and rodents

The construction of store house and storage should be planned to:

1. avoid the entry of birds and rodents; and
2. have sealed/screened entry of air.

5. Temperature control

The temperature being an important environmental factor influencing the seed's viability and vigour, the temperature should be maintained as low as possible above the critical level by (i) ventilation, (ii) insulation and/or (iii) refrigeration.

Chemical methods:

Pest control by pesticides:

The seeds are often infected by the organisms like bacteria, fungi, mites and insects. Eventually they are damaged or wasted by the loss of vigor and viability. These damages can be controlled by **seed treatment.** Estimated amount of insecticide (DDT or BHC or fumigants) and fungicide (fumigation at regular intervels) may be applied as protectant.

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