

**ECO-FRIENDLY
CHEMICAL PROCESSING OF
TEXTILES
&
ENVIRONMENTAL
MANAGEMENT**

BY

PROF. S.R.EKLAHARE

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CHAPTER 1: ECOSYSTEM & TEXTILES

WHAT IS ECOSYSTEM?

DEFINITION: The ecosystem is defined as natural, self contained system consisting of plants, animals and microorganisms functioning together with physical components of the environment.

There are two main components of ecosystem

- 1) Physical component – Abiotic.
- 2) Living component – Biotic component.

The physical components of ecosystem are temperature, rainfall, light, soil, wind etc.

The Living component of ecosystem are Plants and animals.

The activities of living components effect the physical components e.g. Floods, droughts etc.

In an ecosystem the biological cycling is maintained by three groups viz.

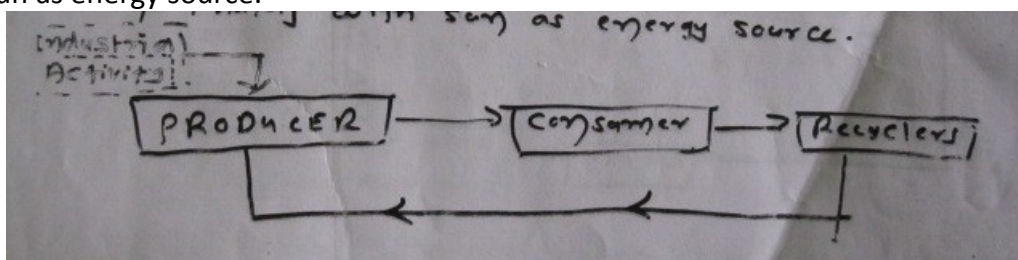
- 1) Producers
- 2) Consumers
- 3) Decomposers or recyclers.

Examples.

- 1) Producers: Plants produce their own food by photosynthesis.
- 2) Consumers: e.g. Animals that obtain their energy directly by grazing, feeding on other animals or both.
- 3) The decomposers/recyclers: These are fungi and bacteria that decompose the organic matter of consumers into inorganic substance that can be reused as food by producers.

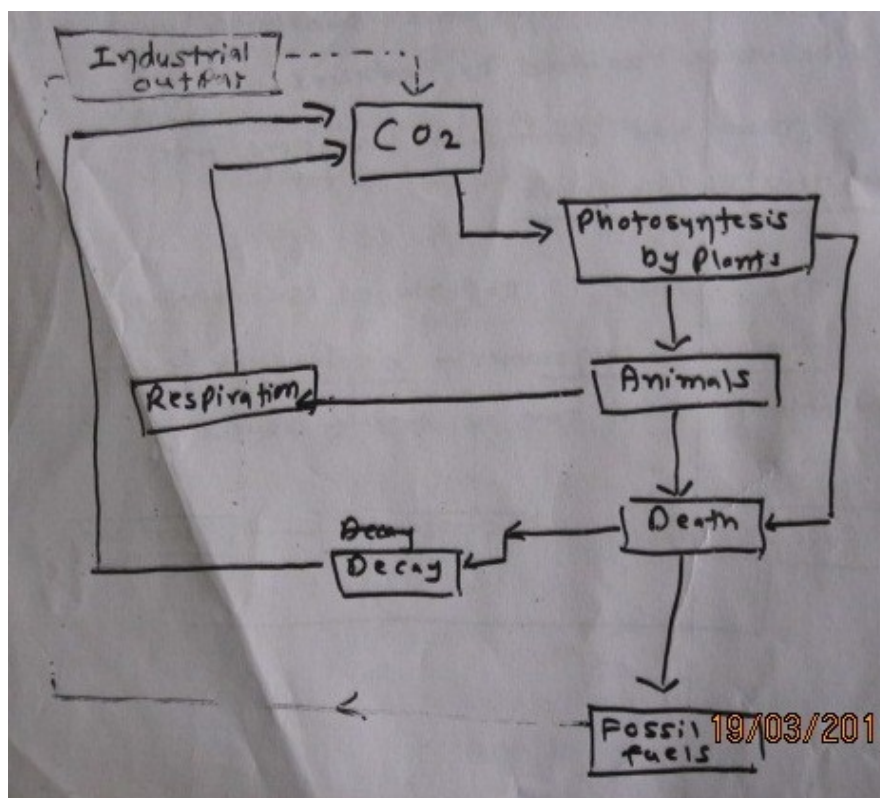
Thus the decomposers/recyclers are 'recyclers of biosphere'.

The nature is capable of sustaining the producer-consumer-decomposer cycle indefinitely with sun as energy source.



CARBON CYCLE:

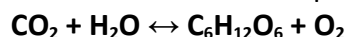
- a) All life is based on element carbon.
- b) Concentration of carbon in living matter is about 18% which is extracted mostly from plants.
- c) Carbon is also major constituent of most organic matter. e.g. Fossil fuels.



Key events in carbon cycles are complimentary to each other.

i.e

Photosynthesis by plants takes CO_2 and water to produce carbohydrates and Oxygen

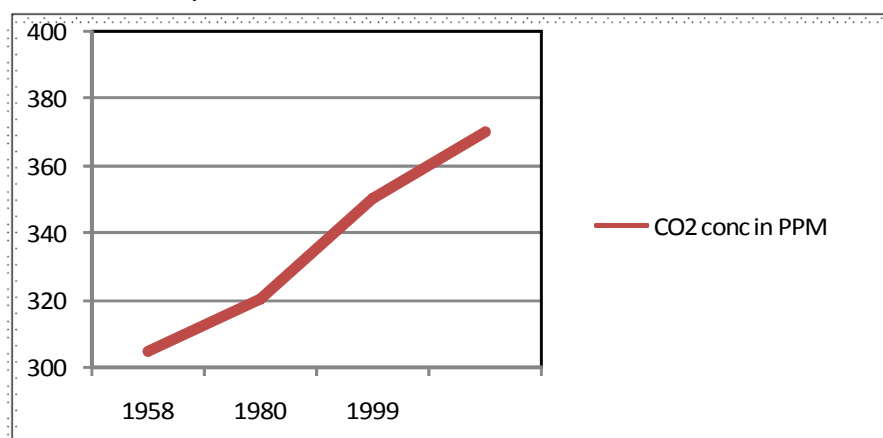


During respiration, carbohydrates and oxygen combines to produce CO_2 , H_2O + Energy.

Thus output of photosynthesis is input of respiration and output of respiration is input of photosynthesis.

Effect of Industrial activity on Carbon Cycle:

- i) Industrial production has increased tremendously since 1950 (Industrial revolution)
- ii) Fossil fuels like coal, crude oil were largely used.
- iii) Deforestation.
- iv) There is increase of CO_2 emission by 34% in last 50 years (From 300 to 400 PPM)
- v) This CO_2 must be recycled which is a cause of concern.



Effect of increased CO₂ emission:

Global warming/green house effect

What is global warming?

1. It refers to average increase in earth's temperature.
2. Earth temperature has increased by 1⁰C in last century.
3. It is expected to rise by 2-3⁰C in 21st century.

This will result in:

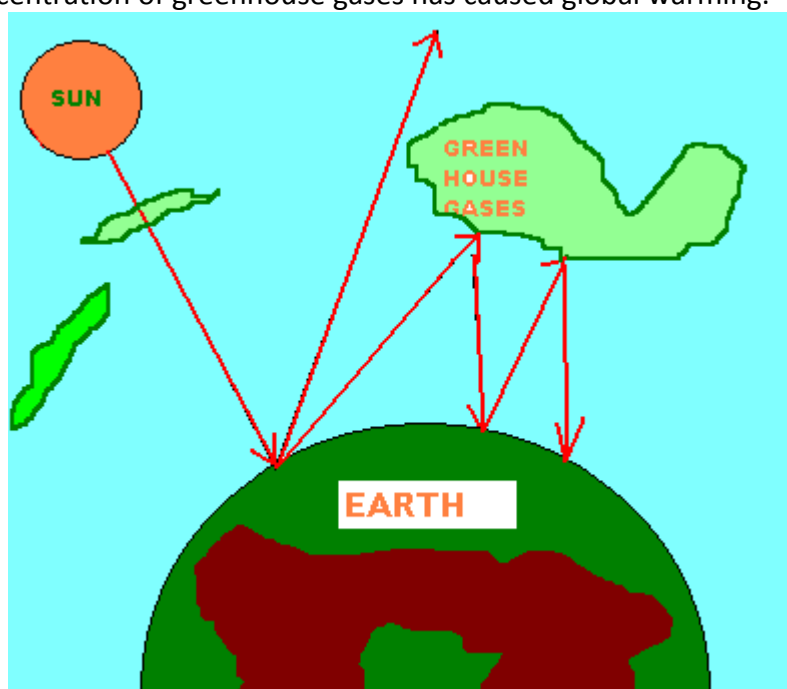
1. Rise in sea level.
2. Melting of glaciers.
3. Extreme weather.
4. Change in agricultural yield.

Green house gases:

CO₂, Methane and Nitrous oxide are green house gases.

What is green house effect?

The green house gases will trap the heat that normally would exit into outer space. The increase in concentration of greenhouse gases has caused global warming.



Two more concepts:

Carbon Footprints:

It is measure of impact of human activities on environment. It relates to all green house gases produced by burning fossil fuels and measured as CO₂ equivalent.

UNIT: Ton or Kg of CO₂ equivalent.

What is CO₂ equivalent?

Every green house gas has global warming potential. It is a global warming potential of green house gas in terms of CO₂ e.g Global warming potential of CO₂ = 1

Methane = 21

Nitrous oxide = 310

It means 1Kg of methane is equivalent of 21 units of CO₂ and 1 Kg of NO₂ is equivalent to 310 units of CO₂.

Hence if 1kg of each CO₂, Methane and NO₂ is emitted its CO₂ equivalent is 1+21+310=332 Carbon dioxide equivalent.

Carbon Trading/Carbon Credit:

- Large companies are allotted quotas of carbon emission.
- If company emits less than quota, it can sell its excess quota to another companies which are likely to cross the quota.
- Also Big company's in developed countries cannot themselves decrease the CO₂ emission because of expensive technology in their country or some other reason,
- Hence they can implement that technology in other country's company where technology is cheap, & hence lead to lower overall emission.

X-TRA GYAN

- 1) *Dr. Rajendra Pauchare is the Head of IPCC (Intergovernmental panel for climate change) as of 2011, run by UNO. He is noble prize winner of 2009.*
- 2) *BT Brinjal: It is genetically modified brinjal. BT stands for Bacillus Thuringensis genes into brinjal seeds.*

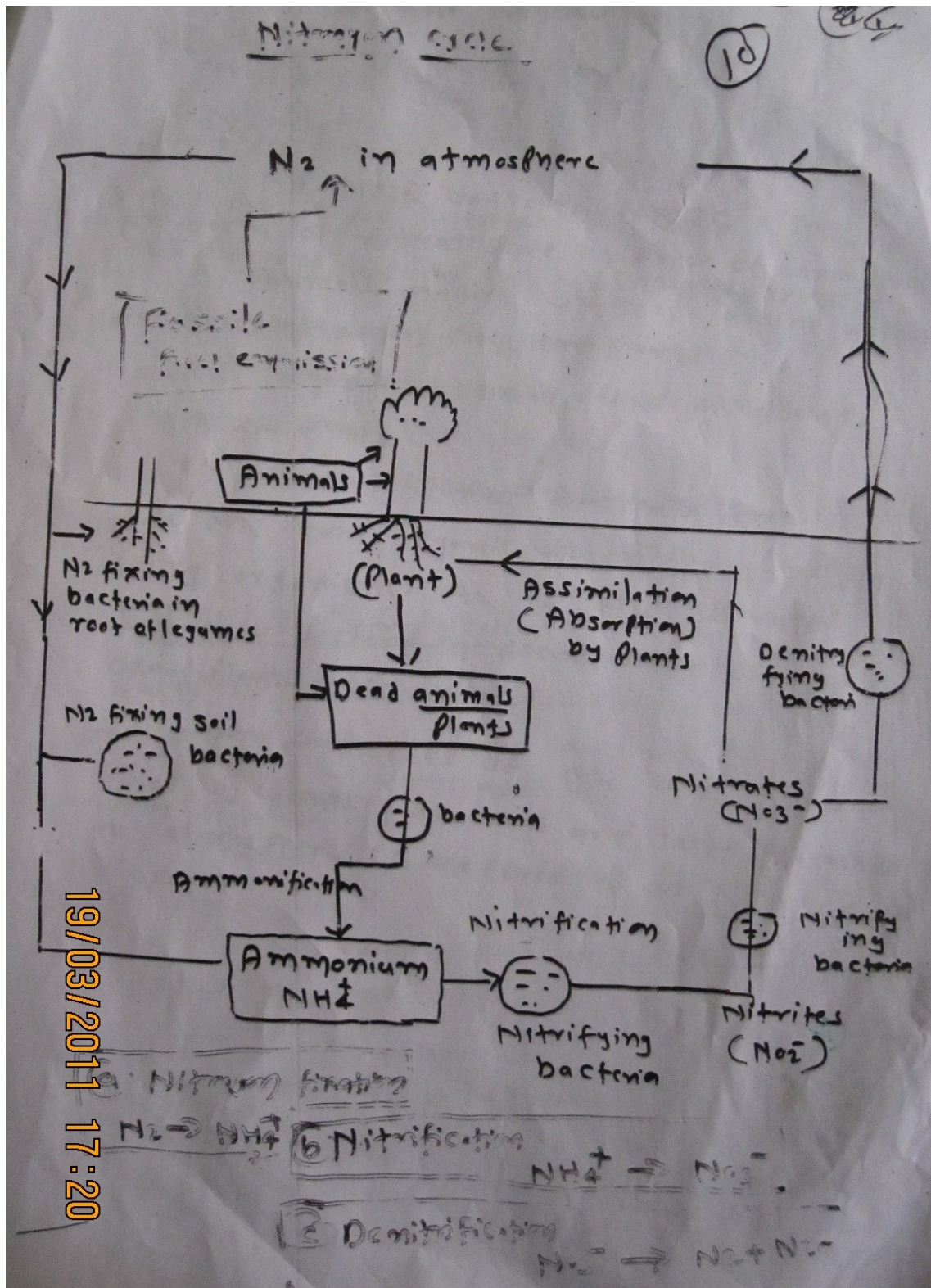
NITROGEN CYCLE:

- 1) Nitrogen is most abundant element in earth's atmosphere. Approximately 78% of atmosphere is comprised of Nitrogen.
- 2) Nitrogen is needed by animals in form of proteins or amino acids.
- 3) Nitrogen in its gaseous form is almost entirely unusable by animals.
- 4) Nitrogen must be converted or 'fixed' into more useful form. This process of converting Nitrogen into more useful form for plants and animals is called fixation.

Process of fixation of Nitrogen:

There are specialized bacteria whose function is to fix Nitrogen in soil. These bacteria are present in 3 forms

- 1) Some are free living in soil.
- 2) Some are associated with roots of bean plant and other legumes like soyabean, peas, peanuts etc.
- 3) Third form is blue green algae found in water.



Lightning also provides energy to fix Nitrogen during rainy season.

Nitrogen Cycle:

All these bacteria fix Nitrogen either in form of Nitrates or in form of ammonia (absorbed by plants).

Animals acquire all their amino acids when they eat plants. Organisms that feed on plants get their Nitrogen.

Denitrification bacterial frees the Nitrogen from organic wastes generated by living organisms. Nitrogen is also liberated by these bacteria by decomposition of plants and animals.

The process of Nitrogen being fixed, used by plants and animals and later returned to atmosphere is referred as “Nitrogen Cycle”

The activities of human have severely altered the Nitrogen cycle. Some of the major activities are

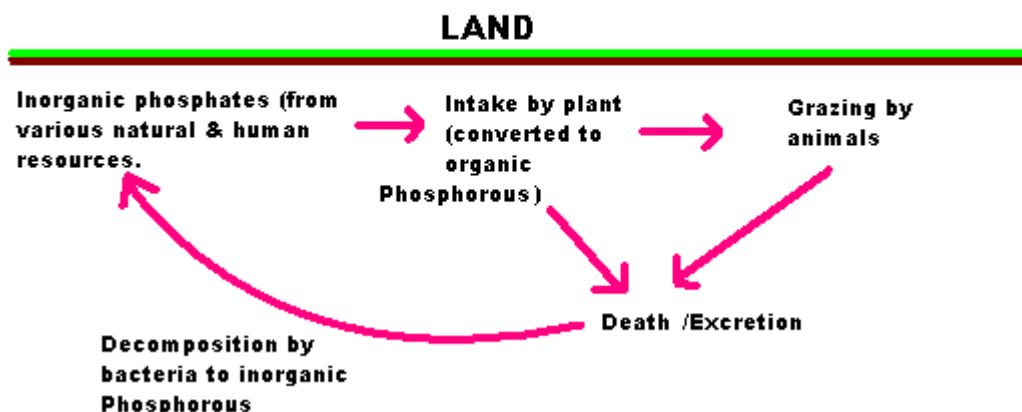
- A) High rate of use of Nitrogen fertilizers. This has caused increased rate of denitrification and leaching nitrate into ground water.
- B) This additional nitrogen entering the ground water system eventually flow into streams, rivers and lakes This added nitrogen can lead to EUTROPHICATION.

What is EUTROPHICATION?

- 1) Bookish definition is *“Depletion of oxygen in a nutrient-rich body of water by growth of too much plant life, leading to death of animal life”*
 - 2) Eutrophication is caused by excessive amount on Nitrogen in organic compounds from fertilizers that are not absorbed by plants and washed into nearby river and lakes.
 - 3) These organic compounds promote growth of algae.
 - 4) Algae may cover entire water surface preventing light from penetrating into water. Due to this algae cell die and reduces dissolved Oxygen in water. This further leads to large scale deaths of fish in lake.
- C) Increased decomposition of Nitrogen in atmosphere by fossil fuel combustion and forest burning.
- D) Live Stock Ranching: Large areas of forest are cleared by grass e.g. cattle ranching accounted for over 70% of deforestation in Brazil. Live stock release a large amount of ammonia into environment from their waste.

PHOSPHOROUS CYCLE:

- Phosphorus is essential nutrient for plants and animals in form of ions.
- Phosphorous does not enter the atmosphere as gas.
- It remains mostly on lands, in rock and soil mineral.
- At normal temperature it is solid in form of red and white phosphorous.



- 1) Inorganic phosphates are converted to organic phosphorous by plants and absorbed.
- 2) Animals eat these plants.
- 3) Death of plants/animals and excretion is converted to inorganic phosphorous by bacteria.
- 4) All this cycle takes place inside soil.

Human Interference:

- Use of excessive phosphate fertilizers.
- This results in Eutrophication i.e. excessive amount of phosphorous enters in lakes, developing algae and reducing Oxygen content in lakes.

CURRENT ECO-SYSTEM PROBLEMS AND HUMAN HEALTH:

1) GLOBAL WARMING:

Due to increase in green house gases like CO₂/Methane/Nitrous oxide in atmosphere.

This will result in

- a) Rise in sea level
- b) Melting of glaciers

2) OZONE LAYER DEPLETION:

UV radiations entering the earth atmosphere causing

- a) Skin cancer
- b) Eye cataracts
- c) Reduction in immunity.

3) POLLUTION OF RIVERS/LAKES:

- It is due to industrial activity and excessive use of fertilizers.
- This will result in reduction in number of fish species and aquatic life.

4) ACID RAIN:

- Rain water with pH values lower than 5.7. This is primarily due to emissions of CO₂/SO₂ (due to excessive use of fossil fuels).
- This will affect agricultural yield.

5) **UNEVEN RAIN:**

Floods/droughts will again result in drop in agricultural production.

6) **DEFORESTRATION:**

Cutting of trees and jungles for use as fuel/ranching.

- This has resulted in increase of concentration of CO₂ in air (global warming).
- Many animal and plant population have declined in number.
- Continued reduction in number of bird species.

7) **Spread of new diseases like H1N1 (Swine flue)**

8) **Masses are still dying by diseases like malaria.**

9) **Land erosion.**

THREE TYPES OF ECOLOGICAL ASSESSMENT:

Hazard Assessment:

- a) This is assessment of ecological impact of the product used in industry.
- b) The products have to be marked as hazard class/ecofriendly class.
- c) 1st step to improve environment.
- d) Here the approach is to use only ecofriendly products to solve the problem
- e) This is not enough when safe products with required properties are not available.

Selection of risk assessment:

- a) Here the importance is also given to new processing routes, available infrastructure.
- b) Here the hazardous substance can be used depending on process route.
- c) E.g Toxicity of dye is not important if it is completely and irreversibly bound to fibre and also not affecting the person weaving the fabric.

Risk Management:

Here the risk of using the toxic substance is taken but it is also managed successfully by

- a) Use of new technology to solve water and air pollution problems.
e.g. Biological purification plants with better adapted bacteria and use of membrane technique.
- b) This method usually requires new plants and requires investment.

ECOLOGY & TEXTILES:

Textile industry mostly produces 3 types of pollution

- 1) Air
- 2) Water
- 3) Sound

1) **AIR POLLUTION:**

- a) Cotton dust and fluff from spinning/weaving department.
- b) Boiler flue gases and smoke

- c) Kerosene vapors from polymerizing machine.
- d) Chemical vapors from finishing machine
- e) Chlorine vapors.

2) WATER POLLUTION:

- a) **Sizing:** pH 8-9.5, BOD-1000mg/l
- b) **Desizing:** pH Neutral, BOD 35% of total BOD
- c) **Scouring:** 30% of water used in a process house, COD 35% of total COD.
- d) **Mercerization:** Most of caustic soda is recovered. pH of effluent is 12-13.5, BOD & COD is low.
- e) **Dyeing:** Colored effluent & Contains excess suspended/dissolved solids. High COD
- f) **Printing:** Unfixed dyes, starch, gums in effluent. High BOD due to thickening.
- g) **Finishing:** Less waste water, Low BOD.

3) SOUND POLLUTION:

Sound pollution is a major problem from machines in Spinning and weaving department.

TOXICOLOGICAL CONSIDERATION OF TEXTILE PROCESSING

I. FORMALDEHYDE:

Source: Dye fixing agents/Resin finishing.

Limits: 100mg/kg for textiles directly in contact with skin

300mg/kg for textiles not directly in contact with skin.

Effects: Weakens the immune system & Suspected carcinogen

II. PCB- Pentachlorobenzene/Trichlorobenzene.

Used as

- Fungicide in cotton.
- Solvents in manufacturing of dyes.

Limits: It should not be traceable.

Effects: Central nervous system.

III. HEAVY METALS:

Cadmium, Chromium, Cobalt, Lead, Mercury, Zinc etc.

Sources: Dyes and pigments.

Limits

HEAVY METAL	LIMITS IN mg/Kg of fabric
Arsenic	1
Lead	1
Cadmium	0.1
Mercury	0.02
Chromium	2
Copper	50

Effect of heavy metals on human health on excessive consumption

- High blood pressure.

- Affects nerves, hormones.
- Effect kidneys.

IV. AZO DYES:

- No clothing item coming in contact with human body be used if they release harmful amines due to use of azo dyes.
- Total of 118 dyes are banned in Germany and other European nations.
- Garments, home textiles (bed sheets, towels), upholstery, seat covers etc are covered under the ban.
- There reason for ban is that they are suspected to be allergic, poisonous and carcinogenic.

V. CHLORINATED CARRIERS:

Chlorinated carriers used in Polyester carrier dyeing also posses health hazard.

VI. STAIN ROMOVERS:

Carbon Tetrachloride (CCl_4) depletes ozone layer.

VII. HYPOCHLORITE BLEACHING:

Limit – 4 mg/l of Cl in water.

Products V, VI, VII are now banned to be used in Europe.

VIII. KEROSONE:

Source: Pigment printing.

Banned in European markets.

IX. PACKING MATERIALS:

Polyethylene bags disadvantages:

- Manufacturing is not ecofriendly.
- Finished products of polyethylene cannot be degraded easily (Non-biodegradable)

Alternatives: Use paper, jute, hemp, organic cotton.

Treat the seeds with fungicides	Untreated seeds
Synthetic fertilizers are used which leads to loss of soil due to more crop culture.	Build strong soil through crop rotation
Use of large quantity of insecticides	Less use of insecticides (healthy Soil)

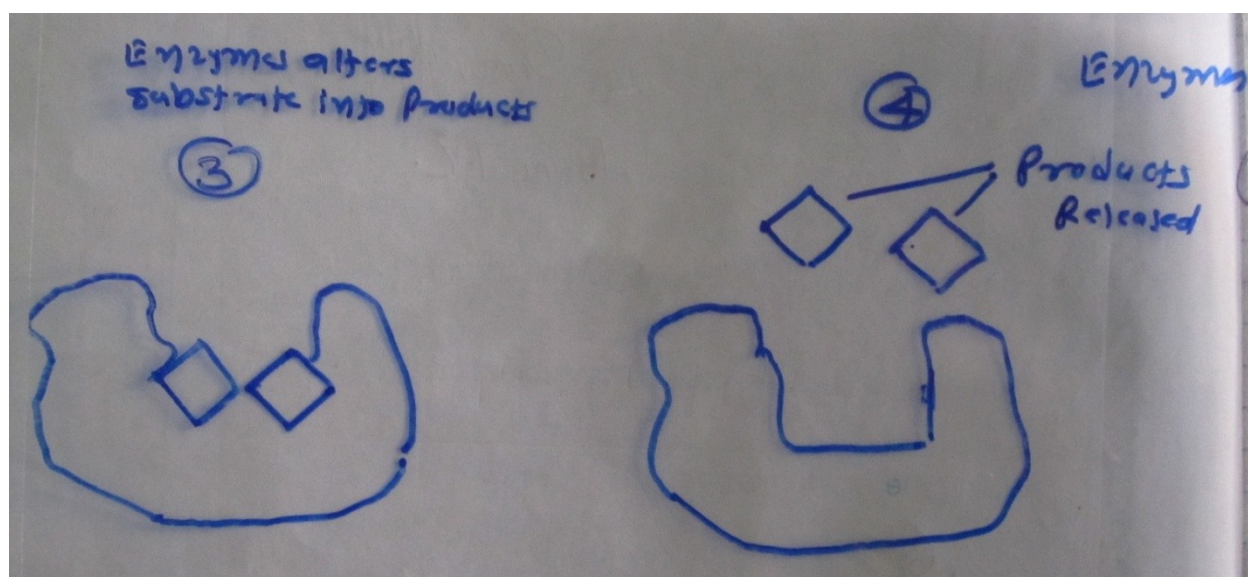
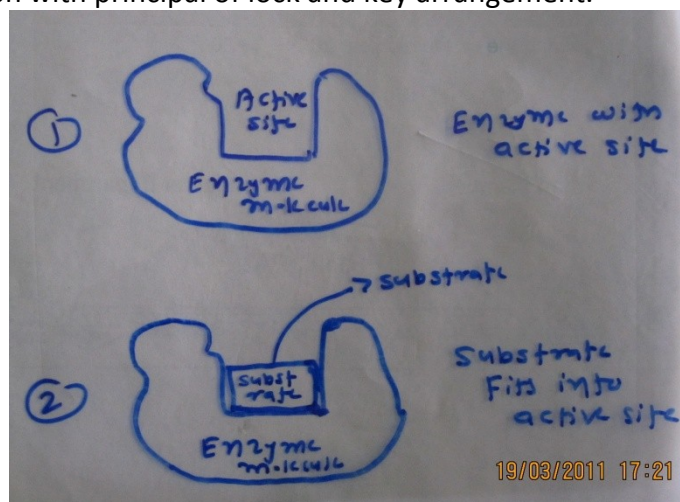
CHAPTER 2: ECO FRIENDLY PRETREATMENTS

CONCEPT OF ENZYMES

Enzymes are high molecular weight protein secreted by living organisms capable of catalyzing the chemical reactions of biological process. The protein complex is composed of 200-250 amino acids.

Properties of Enzyme:

- All enzymes are proteins and are water soluble.
- Each enzyme has specific catalytic action.
- They work at specific temperature/pH.
- Abnormal conditions reduce their activity.
- Their molecules are round in shape.
- They have pockets shaped gap-called active site.
- They function with principal of lock and key arrangement.



The mechanism of working of enzymes

- Substrate fits exactly into active site (fig2).
- Enzymes join with substrate for short while.
- Enzymes alter substrate into products and products are released (fig3/4).
- Enzymes are not used in the process and continue action if more substrate is provided.

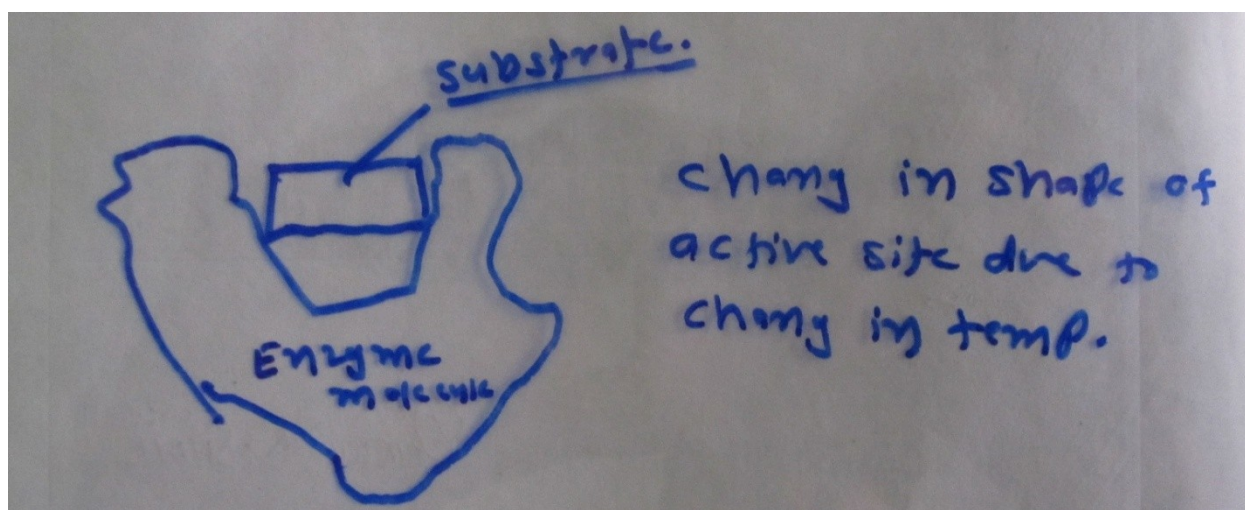
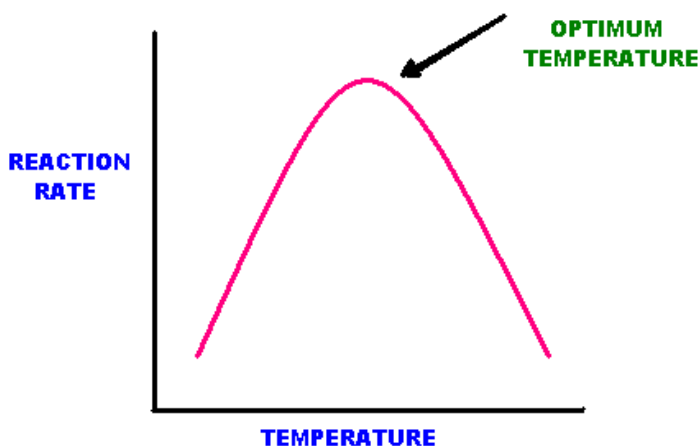
$E + S \rightarrow ES$ (Enzyme substrate products)

$ES \rightarrow E + \text{Different products.}$

Factors affecting efficiency of enzymes.

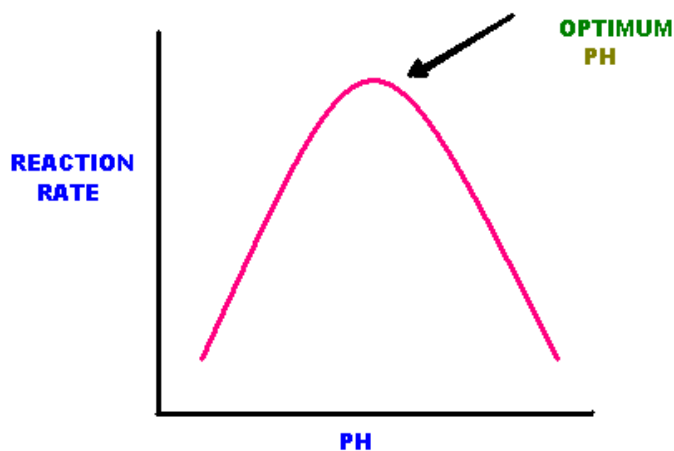
1) Temperature:

- Enzymes work at particular temperature. Change in temperature alter their efficiency. Most of enzymes work at 40-60°C.
- Above optimum temperature, heat alters the shape of enzyme molecule, changing the shape of active site. This leads to reduction in their activity.



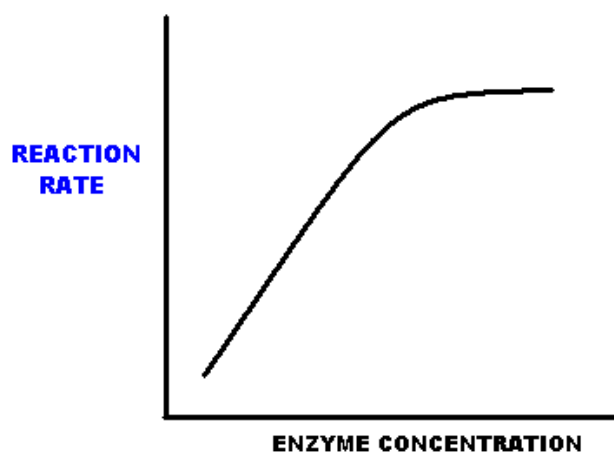
2) **pH:**

- Some enzymes work best in alkaline medium, while some work best in acidic medium for every enzyme there is optimum pH where its activity is highest.



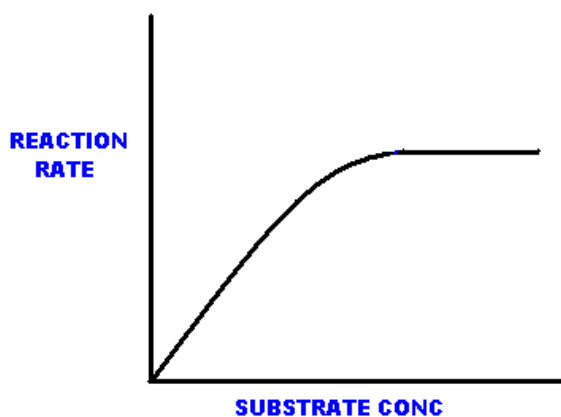
3) **Concentration of Enzymes:**

- Increase in concentration of enzymes increases the reaction rate.



4) **Concentration of substrate:**

- Increase in concentration of substrate increases the reaction rate till certain point.



5) **Concentration of products:**

- Accumulation of products decreases the enzyme activity.

6) **Radiations:**

- Exposure to UV rays, X rays reduce their reactivity.

Classification of Enzymes:

a) **Oxido Reductases:**

These enzymes catalyze oxidation-reduction reactions involving transfer of atom or electrons.

b) **Transferases:**

These enzymes transfer C,N,P or S containing groups from one substrate to another.

c) **Hydrolases:**

These enzymes catalyse cleavage reaction by hydrolysis.

d) **Lyases:**

They nonhydrolically remove group from the substrate with formation of double bond or add new groups across double bond to convert it into single bond.

e) **Isomerases:**

These enzymes catalyses intermolecular rearrangements to form an isomer. (Isomer –Same molecular formation but different structural formula)

f) **Ligases:**

These split C-C, C-O, C-N, C-S or C-halogen bonds without hydrolysis or oxidation.

ENZYMATIC DESIZING:

CONVENTIONAL DESIZING

A) Acid desizing, B) Oxidative desizing

Disadvantages of acid desizing: May degrade cotton.

Disadvantages of oxidative desizing: Residual peroxide, High pH due to caustic, and high TDS.

ENZYMATIC DESIZING

1) Most commonly used enzymes are AMYLASE.

2) There are two types of AMYLASE

a) α - Amylase b) β -Amylase

α -Amylase hydrolyze randomly and act on 1:4 bond of starch backbone.

β -Amylase release maltoic units from chain ends of starch polymer. These enzymes cannot bypass the branches.

Hence α -Amylase is used for desizing. It is obtained from pancreas or malt extract.

How α -Amylase act?

- a) α -Amylase has two acidic amino acids such as aspartic acid and glutamic acid.
- b) It has also got basic amino residue e.g. Histidine.
- c) Hence the action of enzyme evolves both acidic/Basic hydrolysis of starch.
- d) α -Amylase can be activated by Ca^{+2} ions and hence perform well in hard water..

Desizing methods:

The desizing enzymes are available at various forms which can act right from room temperature (longer period) in batch form to high temperature for continuous desizing.

- a) Enzymatic desizing: (Pad batch method)
 - Pad the fabric with 50gpl enzyme pH 6-7.
 - Batch for 20-24 hours at room temperature.
 - Carry out washing in Jigger.
- b) Desizing using Jigger/Jet.
 - Enzyme concentration – 5%
 - Wetting agent – 1%, pH 6-7%
 - Carry out desizing at temperature 60°C for 1 hour followed by washing.

BIO SCOURING (ENZYMATIC SCOURING)

Composition of cotton.

Cellulose	94%
Protein	1.5%
Pectin	1.4%
Wax	0.5%
Ash	1.2%
Others	1.4%

Conventional method: Alkali scouring.

Where 3-4% caustic soda is used at high temperature (90-95°C) for long duration (2-3hours)

Disadvantages of alkali scouring:

- 1) Damage to fibre.
- 2) Requirement of large quantity of water.
- 3) Heavy effluent load (Salts of neutralization)

Advantages of bioscouring:

- 1) Milder process: No damage to cotton.
- 2) By products readily degradable.
- 3) Less load of effluent of salts.
- 4) Less energy and time.
- 5) Softer handle of fabric.
- 6) Less weight loss with good absorbency.

Enzymes used for Bioscouring:

Pectinase – (Pectins removal)

Protease – (Removal of proteins)

Lipase – (Removal of oils & Fats or waxes)

Combination of 2 or 3 enzymes may be used to get synergistic effect.

Recipe and procedure for Enzymatic scouring.

Enzymatic scouring can be carried out with exhaust as well as continuous method.

Exhaust method:

Enzymes – 1%

Wetting agent – 0.5%

Temperature – 50-60°C

Time – 1 Hours

Continuous Method:

Pad with 10-15 gpl enzyme solution + wetting agent followed by steaming at 100°C for 2-3 minutes.

Comparison between Bioscouring & Conventional scouring.

pH	7-8	12-13
Temperature	50-60°C	95°C
Residual Pectine	20-25%	10-11%
Weight loss	< 1.5%	4-6%
Handle	Very soft	Harsh/Papery.
Rinse water consumption	30-40% of alkaline scouring.	
TDS	50% of alkaline scouring	
BOD	50% of alkaline scouring	
COD	50% of alkaline scouring	

ENZYMATIC DEGUMMING OF SILK**Morphology of Silk.**

Silk consist of two fibroin filaments held together by connecting layer of sericin.

Fibroin = 75% wt.

Sericin = 25% wt in raw silk and both are proteins.

Degumming: Removal of sericin layer prior to dyeing/printing or finishing to get bright/lustrous fabric.

a) Conventional Process of degumming:

Alkaline soaping at pH 10-11 at 90-95°C for 1 hours.

- b) Enzymatic degumming:
Advantages: The process is gentle on fibres.
- c) Type of enzyme used: Proteolytic enzymes.
- d) Degumming is carried out at 60°C at pH 8 for 1 hour.
- e) Degumming at which stage
Yarn or Fabric?
Degumming is carried out at yarn stage, if yarn dyeing is to be done. If it is fabric dyeing then sericin in filament yarn work as size in weaving and then degumming is done at fabric stage.
- f) The degumming waste liquor is rich in sericin content and is being used as raw material for the production of sericin powder in cosmetic industry as moisturizer in hair care products.

ENZYMATIC H₂O₂ BLEACHING:

- Bleaching of cellulosic material with enzymes not possible.
- Enzyme can only be used for quicker decomposition of residual H₂O₂ on fabric.
- After H₂O₂ bleaching, if residual peroxide is not removed and dyeing is done in same bath, it will result in reduction in colour yield (drop in depth of shade).
- Hence the fabric needs to be washed several times before dyeing, resulting in high water consumption.
- Hence enzyme are used to decompose residual H₂O₂
- Enzyme used is Catalase

The procedure for H₂O₂ bath clean up

- Drain the bleaching liquor.
- Fill with fresh water.
- Adjust pH for dyeing.
- Add 1gpl catalase enzyme.
- Check H₂O₂% in bath after 10 min.
- Start dyeing in same liquor.

The rinsing is not required, when enzyme is used as all H₂O₂ has broken down and residual enzyme has no effect on dyestuff.



The various advantages of use of Catalase are:

- No adverse effect on dye.
- No need of heating.
- No rinsing of peroxide bath.
- Saving of water/time.
- Saving of energy.
- Reduced process time.

ECOFRIENDLY STABILIZERS:

Sodium silicate is most commonly used stabilizer for H_2O_2 bleaching.

Disadvantages' of Sodium silicate:

- 1) High pH of effluent.
- 2) High TDS.
- 3) Formation of silica scales on machine parts.

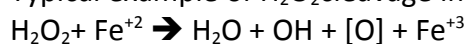
It is most commonly used in H_2O_2 bleaching.

The sodium silicate may be replaced by organic stabilizers like

- a) Polyhydroxy carboxylic acids and their ammonium salts.
- b) Polyacrylic acids.
- c) Polyphosphoric acids and their alkali metals and ammonium salts.

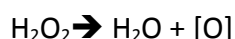
REDOX BLEACHING

- 1) Typical example of H_2O_2 cleavage in presence of reducing agent.



OH Radical is also strong oxidizing group.

- 2) In absence of reducing agent reaction is



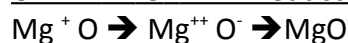
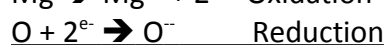
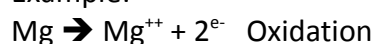
Oxidation:

- Addition of oxygen
- Removal of Hydrogen or Removal of electrons.

Reduction:

- Removal of oxygen
- Addition of Hydrogen or Addition of electrons.

Example:



REDOX BLEACHING:

One step Desizing/Scouring/Bleaching.

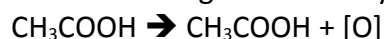
- 1) STEP I – Alkali desizing at boil 30-45 min.
- 2) STEP II – 2nd installment of alkali for scouring + External reducing agents like, hydro, bisulphate, glucose desizing will also generate Dextrine, Maltose, Fructose (Reducing agents). Reducing agents help/accelerate bleaching process.
- 3) Addition of peroxide in same bath i.e. Alkali/Reducing environment with stabilizers for 1-2 hours.

PER ACETIC ACID BLEACHING:

- Per acetic acid is also known as peroxyacetic acid.
- It is colorless in nature.
- It is miscible with water and most of organic solvents.
- It is very powerful oxidizing agent.
- It is also used as germicide for protecting fruits/vegetables against spoilage.
- General formula is $C_2H_4O_3$.
- It corresponds to acetic acid with additional oxygen atom per molecule.
- i.e. CH_3COOOH (peracetic acid)
- It is highly unstable at pH 5-5.5.
- But stable at lower pH of 1.5-2.
- A concentration of 35% to 40% is dangerously explosive.

Mechanism of oxidation with peracetic acid.

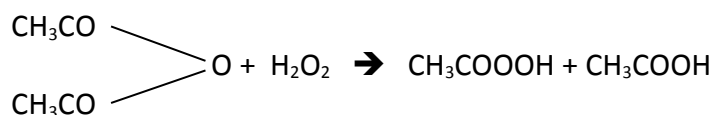
Peracetic acid gives extra oxygen atom and acetic acid is formed as co-product.

**Preparation of peracetic acid:**

Peracetic acid can be prepared using H_2O_2 with acetic acid or acetic anhydride.



OR

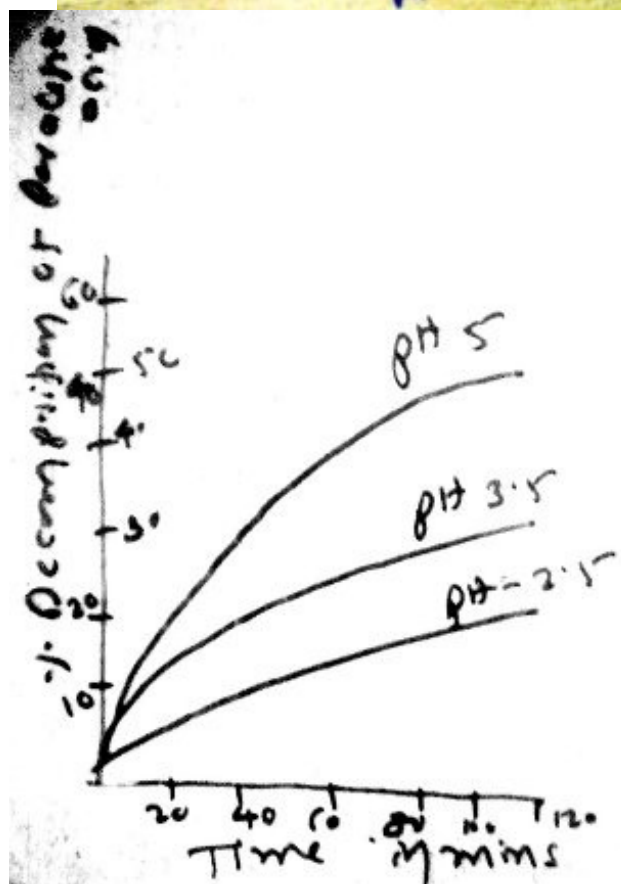
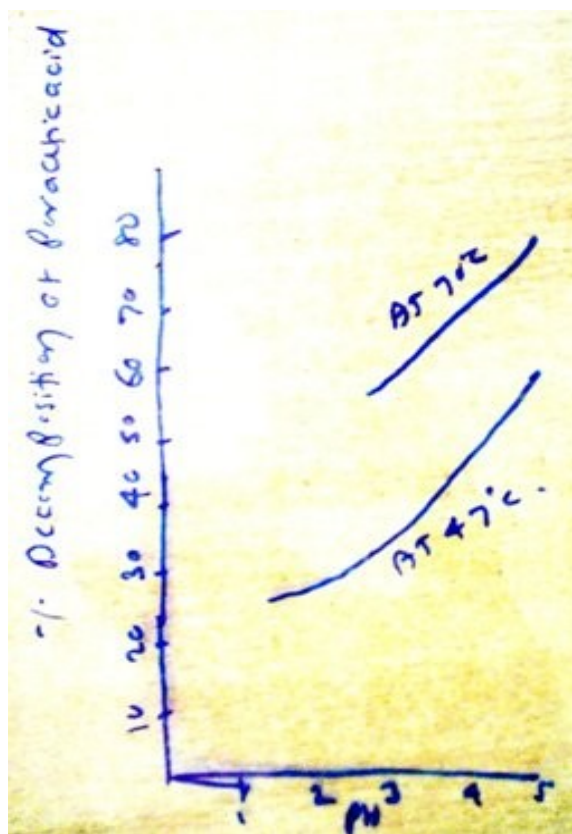
**Procedure for bleaching with peracetic acid:**

- 1) Peracetic acid being unstable has to be prepared before bleaching being carried out as per above procedure.
- 2) Bleaching is carried out with

Peracetic acid (15%)	2.5gpl
Sequestering agent	0.5%
Stabilizers	0.5%
pH	6-7
Temperature	60-70°C
Time	60 minutes

- 3) After bleaching sample is rinsed and dried.

Kinetics of decomposition of Peracetic acid:



ECOFRIENDLY RETTING OF JUTE

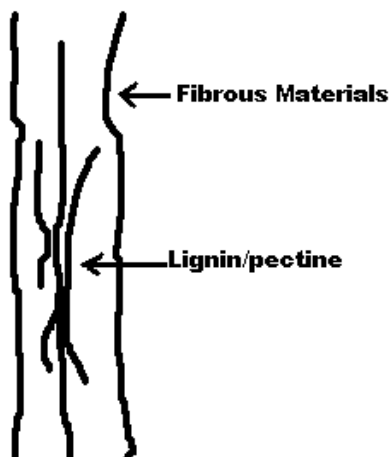
What is retting?

To remove jute fibre from woody core and impurities.

It is done by two methods.

Dew Retting:

- Stalks about 1 meter in height are collected by hand
- They are sprayed on ground
- They are exposed to air/water for 3-4 weeks.
- Under these conditions mould and bacteria develop which attack pectin/Lignin.



Disadvantage:

- The process is very slow.
- Certain microorganisms produce pigments and change the colour.
- Cellulose is also attacked and fibre becomes weak.

Water Retting:

- Plants are immersed in flowing water for 2 weeks.
- Mechanism of retting as same as dew retting but the process is fast.
- After retting stalks are gathered and hit with long hammer to loose the fibre.
- Then they are washed with water flowed by squeezing with hand.
- This process is repeated 3-4 times till all decomposed pectin lignin is washed off.
- This is followed by drying and spinning.

Enzymatic Retting:

It is generally not done as it is not a high value crop.

The enzymatic retting is carried out with enzymes.

Lignase	5gpl
Protase	5gpl
Cellulase	1gpl

At 60°C, pH of 7 for 1-2 hours.

- Enzymatic desizing is done only when high value blended yarn or yarn for geotextile is made.

CHAPTER 3: ECOFRIENDLY DYES AND DYEING

REQUIREMENTS OF ECOFRIENDLY DYES AND DYEING:

- 1) Biodegradable dyes.
- 2) Ecofriendly auxiliaries.
- 3) No harm to Human being on use.

TYPES OF POLLUTANTS ASSOCIATED WITH VARIOUS COLOURING PROCESS

SUBSTRATE	DYE	TYPE OF POLLUTANT
	Direct	Salt, Unfixed dyes (3-30%)
	Reactive	Salt, Alkali, Unfixed dyes (5-30%)
	Vat	Alkali, Oxidizing agents, Reducing agents.
	Sulphur	Alkali, Oxidizing agents, Reducing agents.
	Chrome	Acids, Heavy metal, Salts, Unfixed dye
	1:2 Metal Complex	Acids, Unfixed dye
	Disperse	Acids, Unfixed dye (~ 5%)

ECOFRIENDLYLY DISPERSE DYES:

- a) Disperse dyes exhaustion is between 95-96%. Hence the amount of dye discharged is very less compared to cotton dyes.
- b) The effluent containing disperse dye increases TDS (5-7%)
- c) The pH of effluent is about 6.
- d) The reduction clearing process causes some load on TDS.
- e) Amount of water required is much less compared to cotton dyeing

TDS (Total Dissolved Solids) are solids in water that can pass through a filter of 0.45 micrometer.

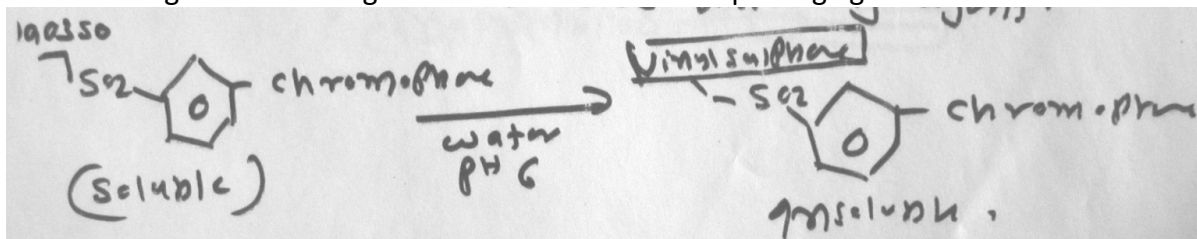
Permissible limit of TDS = 2100mg/L

Permissible limit of Suspended solids = 100mg/L

Ecofriendly Disperse dyeing:

- a) Do not use banned Azo/Anthraquinone dyes. Some disperse dyes like C.I Disperse orange 76, C.I. Disperse orange 37 were found to be potentially allergic. They are replaced by C.I. Disperse orange 29, 30, 44, 61.
- b) Do not use chlorinated carriers.
- c) Use of low liquor dyeing (1:3)
- d) Continuous ranges for dyeing whenever possible. Use Pad-Thermofixation method.
- e) Temporarily solubilized disperse dyes (Patented)

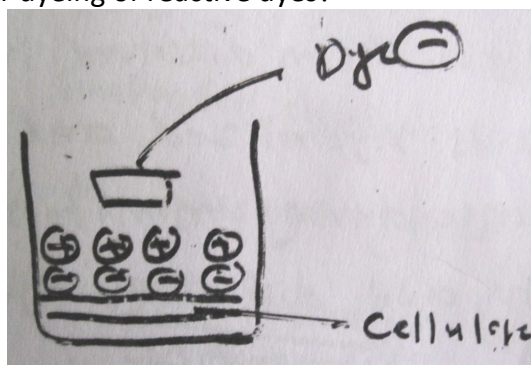
They contain β -Sulfatoethyl sulfoxy group which solubilize the disperse dyes when dissolved in water at pH 6, this group is hydrolyzed and dye becomes insoluble. Hence during manufacturing there is no need to add dispersing agent.



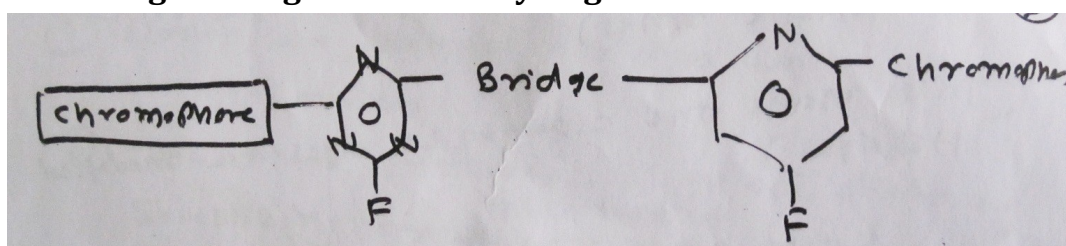
- f) Use of Green acid (Formic acid) in place of Acetic acid.

ECOFRIENDLY REACTIVE DYE:

- What is substantivity?
It is defined as attraction between the fibre and dye under given dyeing conditions. In simple words it indicates the ability of a dye to go from solution phase to fibre.
- Relation between substantivity and solubility?
More the solubility less is substantivity.
- Diffusion of dye:
It depends on molecular engineering. Linear structure will help in quick diffusion.
- Why salt is needed for dyeing of reactive dyes?



Molecular engineering for low salt dyeing:



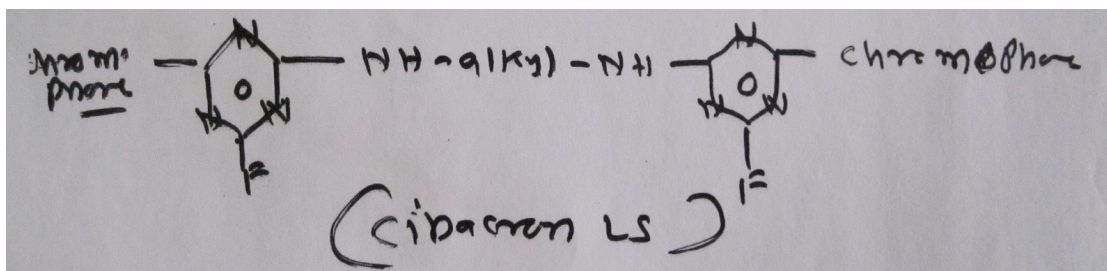
Chromophore:

No of Sulphonic groups in chromophore are optimized to give required solubility but high substantivity.

Bridge: It allows molecular flexibility i.e. easy diffusion.

Reactivity: Introduction of two fluorine groups with a very high reactivity. (Chlorine is replaced by Fluorine).

Example of this dye is Cibacron LS dye.



(In HE dyes there are two Chlorine groups in two triazine rings) This means cibacron LS dyes are modified HE Dyes.

Some other options for ecofriendly reactive dyeing:

- 1) Shift production from exhaust to pad system.
- 2) Recycling of dye bath.
- 3) Separation of slats by reverse osmosis.
- 4) Use of quaternary ammonium compounds to increase the affinity.

ECOFRIENDLY DIRECT DYES:

1. Do not use banned Azo dyes which liberate harmful amines.
2. The other principle is to use optimized solubilizing group in chromophore to give balance between solubility and substantivity.
3. Replace exhaust method by padding method.
4. Recycling of dye bath.
5. Recovery of salt by reverse osmosis.

ECOFRIENDLY SULPHUR DYEING:

- Exact chemical structure of Sulphur dye is unknown till today
- Assumption of sulphur dye structure is as follows.
- R-S-S-R i.e. Bisulphide bonds.

Disadvantages of Sodium Sulphide (Na_2S)

- Cheap but bad smell.
- Toxic.
- It contaminates sea/river and destroys marine life
- High COD.
- International standard for discharge is 2 PPM.

Solutions to Sulphide problem:

- Recovery of sulphides from effluent. But it requires costly equipments.
- Replacement of Na_2S

Strategy:

- 1) Redox potential i.e. Replace Na_2S with reducing agents having same reduction potential.

Replace Na₂S by Glucose:

Redox potential of Na₂S is – 600mv.

Redox potential of Glucose is -700mv.

However limitations of glucose are:

- Highly unstable compared to Na₂S.
- Works only at high pH of 11-12.
- Quantity of glucose required is about 2 times for black and 2.5 times for Navy.
- Less yield of dye.
- Narrow range of reduction conditions.
- Costly

Dye (Paste with TRO)	8%	5%
Soda ash (To neutralize the liberated acids in soda ash)	Equal as dye	Equal as dye
Caustic soda	pH 11-12	pH 11-12
Glucose	Two times of dye	2.5 times of dye.

Carry out reduction at 70°C for 20 minutes, followed by dyeing at boil for 1 hour, followed by oxidation and soaping.

Hydrol:

- It has same potential as Na₂S.
- It is a byproduct of maize starch industry.
- It contains 50% reducing sugars.
- Cheaper than glucose.
- 65 parts of Hydrol + 25 parts of caustic reduces 100 parts of Sulphur dye at 80°C at pH 10

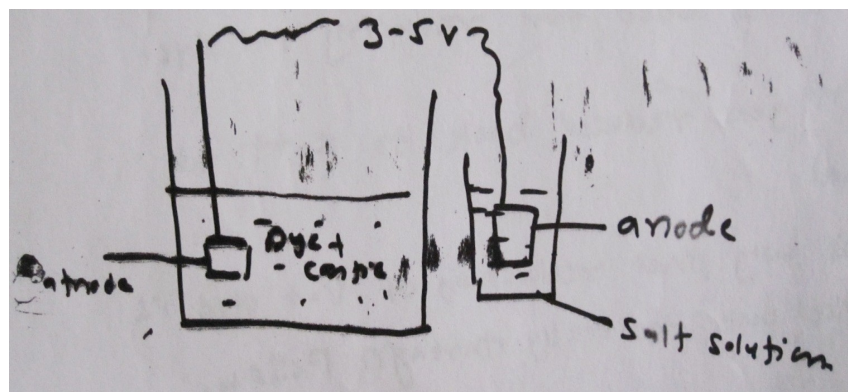
ECOFRIENDLY VAT DYEING:

- Sodium hydrosulphite (Na₂S₂O₄) is used as reducing agents.
- Redox potential of Na₂S₂O₄ is -1000 to -1100mv.
- Strong reducing conditions required.

Electrolytic reduction of Vat dye:**Direct Method**

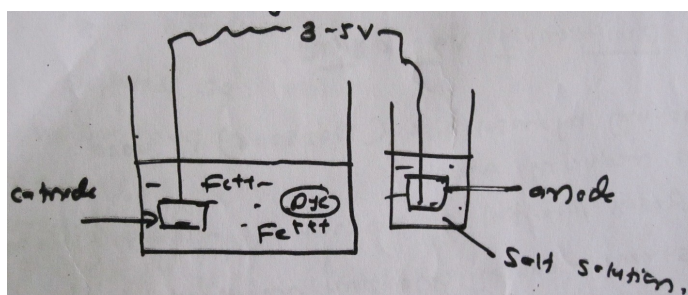
Principle: Vat dye can be reduced in present of caustic soda using electrolytic cell.

Vat dye will accept the electrons at cathode and get reduced.



Limitation: As dye moves away from cathode, it may get oxidized.

INDIRECT METHOD:



- Here FeSO_4 is used as electrolyte along with vat dye + caustic soda.
- Fe^{++} gets oxidized to Fe^{+++} liberating e^- while reacting with vat dye.
 $\text{Fe}^{++} \rightarrow \text{Fe}^{+++} + e^-$
 This e^- is used for reducing vat dye.
- Fe^{+++} gets reduced to Fe^{++} at cathode.
- This way the reduction of vat dye is carried out indirectly through FeSO_4 .

Redox potential of $\text{Na}_2\text{S}_2\text{O}_4$ is -1000 to -1100mv.

Glucose cannot be used in most of vat dyes except yellows or we need to use it in very high quantities.

The other ecofriendly reducing agents with similar redox potential are

- Hydroxyacetone.
- Mercaptoethanol.
- Sulphinic acid.

ULTRASONIC ASSISTED WET PROCESSING:

- 1) What is ultrasonic wave?
- 2) How it is produced?
- 3) Uses?

FREQUENCY	NAME OF THE RANGE
<20Hz	Intrasonic range
20HZ to 20KH	Audible range
>20KHz (20KHz to 500MHz)	Ultrasonic range

Higher the frequency, shorter the wavelength.

What is frequency?

→ It is the number of cycles per second.

What is Compression and rarefactions?

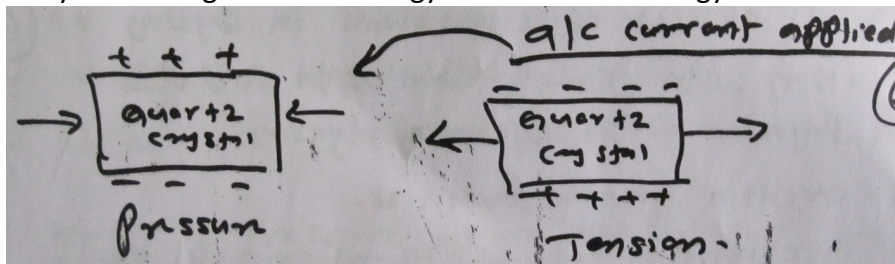
- It is the areas of high & low local pressure e.g. Ultrasound.



- Gives rise to cavities and bubbles.
- Create shock waves.
- Formation of bubble and its collapse and is responsible for ultrasonic effect in solid/liquid.

How ultrasound is produced?

It is produced by converting electrical energy to mechanical energy.



Non textile uses of ultrasonic sound?

- Ultrasound scanning in medical uses low frequency i.e. 20 KHz.
- For measuring sea depth i.e. SONAR devices.
- Hairline cracks in solids/pipes.
- Cutting/welding.

Textile applications:

- Cleaning of textiles.
- Reduces average size of dye particles.
- Reduces glass transition temperature (T_g)
- Increase the swelling of cellulosic fibres. (Unmercerized-50%).
- Swelling is retained upto 1 hour after removal of ultrasound.

Wet processing application.

- Use of electricity in place of expensive thermal energy.
- Can be applied in desizing, scouring, bleaching, washing, dyeing and finishing.
- Trials of use of ultrasonic in dyeing of cotton with direct, wool with acid dyes and polyester with disperse dyes.
- Creates greater evenness.

- A frequency of 20 KHz is suitable to produce cavitations.
- Creation of micro bubbles (Unstable) or cavities .
- Most suitable for polyester.
 - a) Break the dye particles.
 - b) Stabilize the dispersion.
 - c) Reduces T_g (Glass transition temperature).
 - d) Accelerates diffusion.

Advantages:

1. Low temperature dyeing leads to energy savings.
2. Reduced processing time.
3. Reduced consumption of auxiliaries/chemicals.
4. Increased colour yield.
5. Less effluent load.

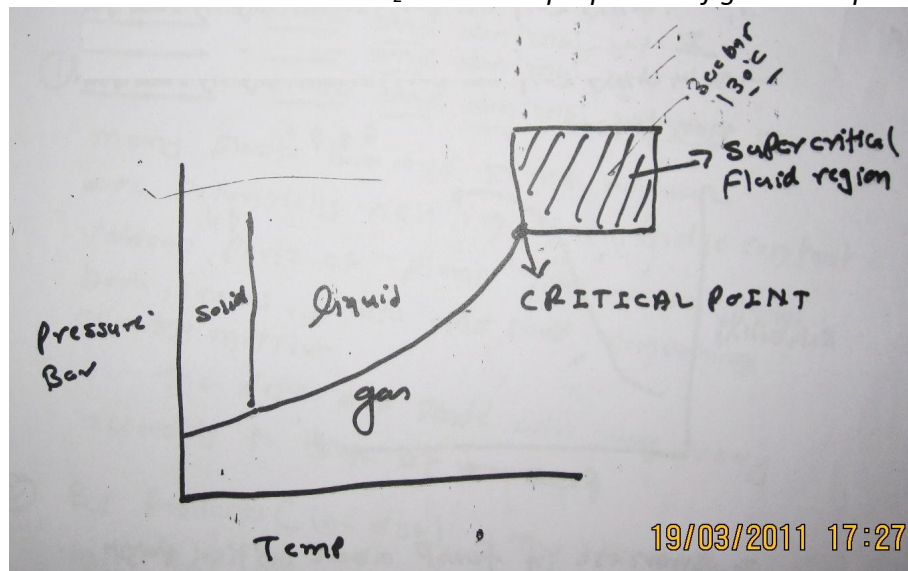
Limitations:

1. Only laboratory trials.
2. More effective for water insoluble dyes.

DYEING WITH SUPERCRITICAL CO₂

- What is supercritical gas (CO₂)?
- What is critical point?

Temperature & Pressure above which CO₂ have both properties of gas and liquid.



Properties of Supercritical CO₂

- Distinction between gas phase and liquid phase cannot be done.
- Boundary between them is homogeneous.
- Highly solvating property.
- Solvating property depends on pressure.

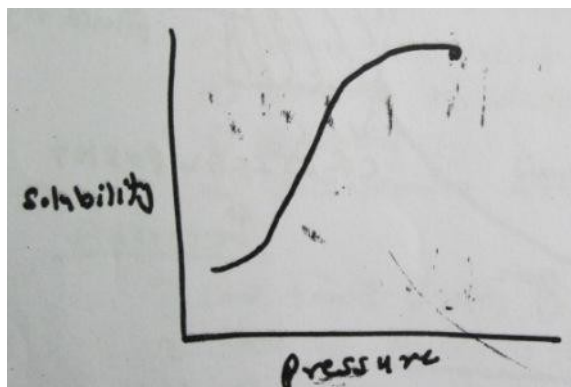
Dyeing with CO₂

Theory:

- Dissolution of dye in supercritical CO₂
- Transport of dye to fibre surface.
- Adsorption.
- Diffusion.

Important factors:

- Solubility can be controlled by pressure.
- It is nonlinear.



- Increase in temperature above critical point reduces density and hence increases solubility.
- Supercritical CO₂ also acts like a carrier.
- At 300 bar T_g (Glass transition temperature) of polyester is reduced by 30°C.

NATURAL DYES:

Definition:

Natural dyes comprise those colours (dyes & Pigments) that are obtained from animal or vegetable matter without chemical processing.

Sources of Natural dyes:

- 1) Specialized plants and animal sources
Many plants and some animals are potentially rich in natural dye content. Various parts of plants like roots, stems, bark, leaves, fruits and seed contains coloring matter. The depth and shade will vary according to time of year.
- 2) By products (lac dye)
The lac industry give lac dye as a byproduct which is extracted from effluent. (Lac: It is by product of insect coccus lacca)
- 3) Attempt has also been made to synthesize natural dye having similar structure.
- 4) Genetic modification of certain fungi have produced Anthraquinone dye.

Classification of Natural dyes:

They are classified by various ways.

a) Substantive and adjective natural dyes.

Substantive: The dyes which can dye the fibre directly without mordant. E.g. Turmeric.

Adjective: These dyes colour the material which is mordanted with metallic salt e.g. logwood.

b) Monogenetic and polygenetic natural dyes.

Monogenetic: Produce only one colour irrespective of mordant present in the fibre.

Polygenetic: Produce different colours according to mordant.

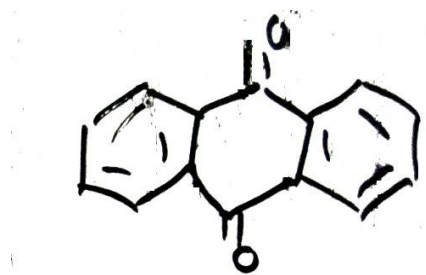
c) Soluble & Insoluble natural dyes.

Soluble: They can be dissolved in water and applied.

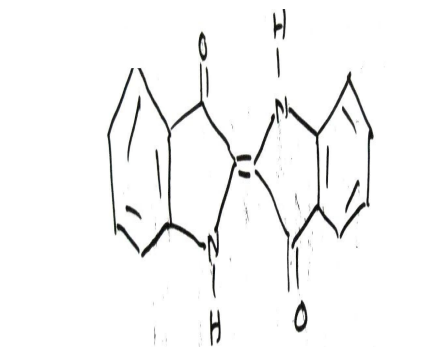
Insoluble: They have no solubilizing group hence temporary solubilizing group is introduced e.g. Indigo.

Classification of natural dyes on basis of chemical structure:

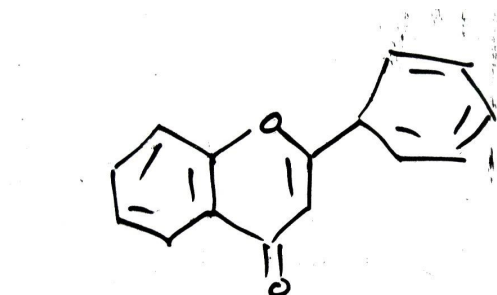
A) Anthraquinone.



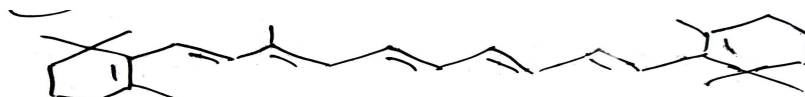
B) Indigo



C) Flavon



D) Carotene



Carotene has long conjugated double bonds.

Classification of mordants.

- 1) **Metallic Mordants:**
Metal salts of Aluminum, Chromium, Iron, Copper and Tin are used.
- 2) **Tannins/Tannic acid:**
It has no natural impurities and used for dyeing light shades.
- 3) **Oil Mordants:**
They are mainly used in dyeing of turkey red colour from madder also known as Wood or Rubia. However alum has to be used as main mordant to dye this colour along with oil mordant.

Limitations of Natural dyes:

- 1) Low colour yield.
- 2) Long time of dyeing.
- 3) High production cost.
- 4) Poor reproducibility.
- 5) Some metallic mordant are hazardous.

Application of various Mordants:

- 1) **ALUM**
 - Addition of alkali to alum solution produces basic aluminium sulphate which is used as mordant.
 - The solution of 1Kg of Alum + 0.5 Kg NaOH + 200 liter water can be used to mordant 10Kg of cotton by direct impregnation.
 - It is not suitable for silk as it reduces luster.
- 2) **CHROMIUM MORDANT**
 - $K_2Cr_2O_7$ is used as mordant mostly for wool.
 - Cheap and easy to apply.
 - 2-4% Dichromate + Tartaric acid is boiled for 90 minutes and used for dyeing wool.
- 3) **COPPER MORDANT**
 - $CuSO_4$ is fixed with the help of Tannin/Tannic acid.
- 4) **IRON MORDANTS**
 - Mostly used for dyeing blacks.
 - These mordants are applied on tannic treated cotton fabric, which forms ferrous tannet.
 - Ferrous tannet is further oxidized in air to form ferric tannet which acts like a mordant.
 - Application is done by padding two times and followed by air oxidation.
 - It is generally used for silk to dye dark shades.

Dyeing with Marigold flower as floral dye on cotton

Dyeing Procedure:

- 1) Dye at 80°C for 1-2 hours.
 - 2) Drying.
 - 3) Soap with 2gpl nonionic soap at room temperature.
- Colour obtained is: Golden Yellow
 - Colour fastness: 3-4
 - This floral dye has no side effect on skin and is cheap.
 - It contains Flavanol

Extraction procedure:

Maximum extraction is done at below given conditions

- 1) 100°C
- 2) Mild basic medium.
- 3) 3 Hours.

Mordants which can be used are Alum, Copper sulphate, Ferrous sulphate.

CHAPTER 4: ECOFRIENDLY FINISHING

ECOFRIENDLY RESIN FINISHING:

- 1) Free Formaldehyde: It is uncombined monomeric formaldehyde that exists in finished solution.
- 2) Formaldehyde release: It is amount of formaldehyde that escapes from fabric into atmosphere.

Factors responsible for formaldehyde release:

- 1) Cellulose readily picks up formaldehyde from atmosphere. This will give positive reading during testing.
- 2) Sources of gaseous formaldehyde are uncured resins. It is difficult to cure 100% but try to get maximum efficiency.
- 3) The third source is cross linking itself. The finish will decompose under certain conditions and liberate formaldehyde.

Formaldehyde Limits:

Baby wear under 2 years	30
Textile in direct contact with skin	100
Textile not in direct contact with skin	300

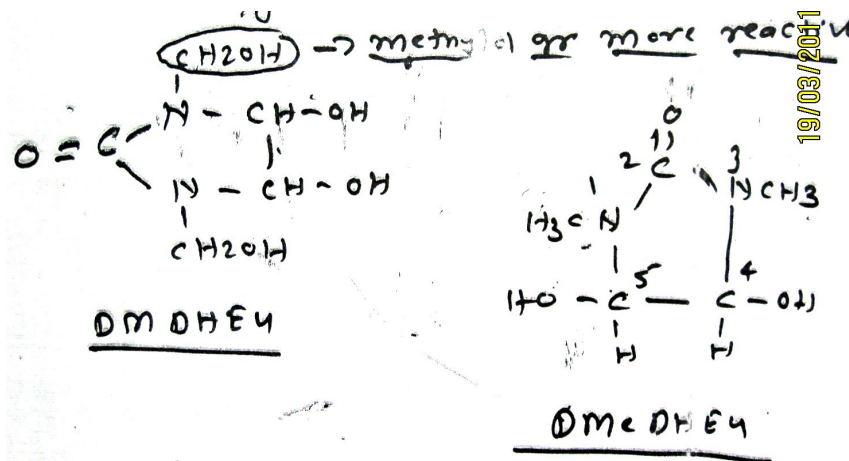
Formaldehyde containing Resins:

- 1) UREA FORMALDEHYDE:
 - E.g. DMU (Dimethoxy methyl urea)
 - Highly reactive.
 - Must be used in few hours in finishing bath.
 - High formaldehyde release.
- 2) MELAMIN FORMALDEHYDE RESINS:
 - Contain 3 to 6 N-Methylol groups connected to melamine ring.
 - It gives higher cross linking.
 - High formaldehyde release.
 - E.g. Tri to Hexamethylol melamine (TMM, HMM)
- 3) GLYOXAL RESINS:
 - Synthesized from urea, glyoxal and formaldehyde.
 - Less reactive than DMU and TMM
 - Therefore requires more active catalyst.
 - Release less formaldehyde than DMU & TMM.
 - E.g. N,N-Dimethylol 4,5 dihydroxy ethylene urea (DMDHEU)

Non formaldehyde containing products:**DMDHEU:**

N,N-Dimethyl 4,5 dihydroxyethylene urea.

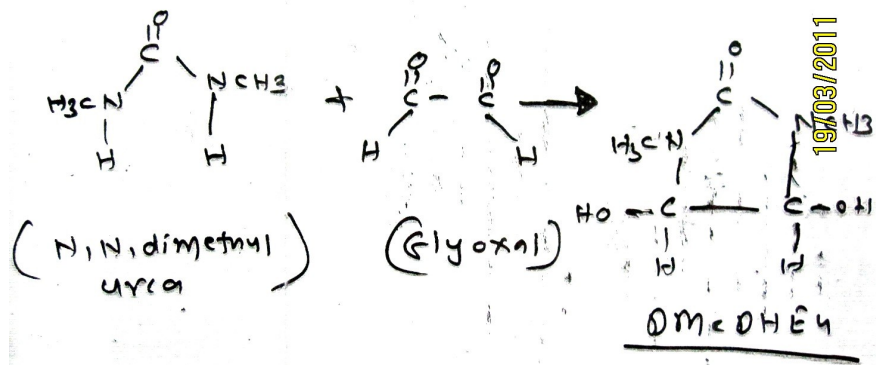
- a) Two hydroxyl groups in 4.5 position are less reactive than N,N methylol group in DMDHEU. Hence stronger conditions required for cross linking.



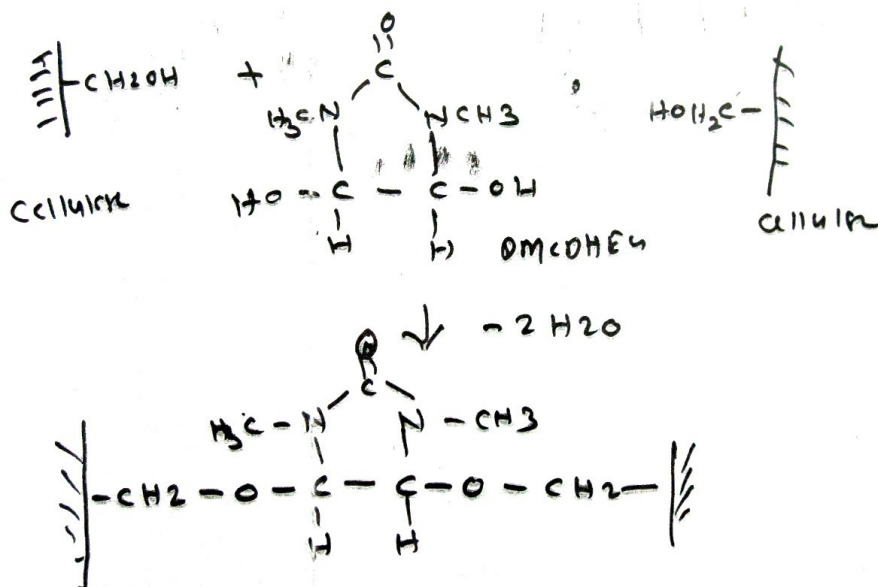
(Steric hinderance)

- b) DMeDHEU does not contain formaldehyde.
- c) Less reactive.
- d) Cost is double than DMDHEU.
- e) Hence mixed with DMDHEU and used.
- f) Catalyst used is MgCl_2 which liberates acid during curing.

DMeDHEU is prepared from relatively expensive N, N dimethyl urea and glyoxal.



Crosslinking with DMeDHEU:

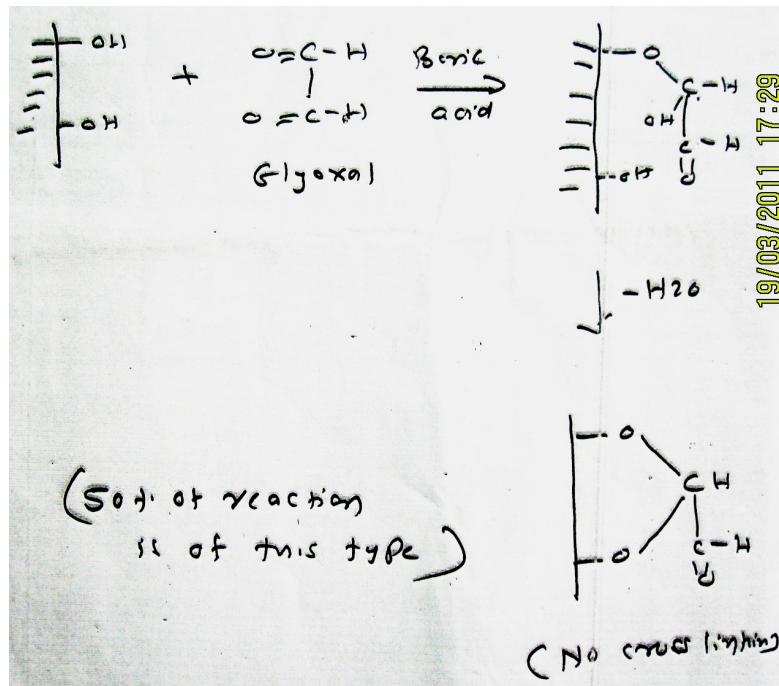


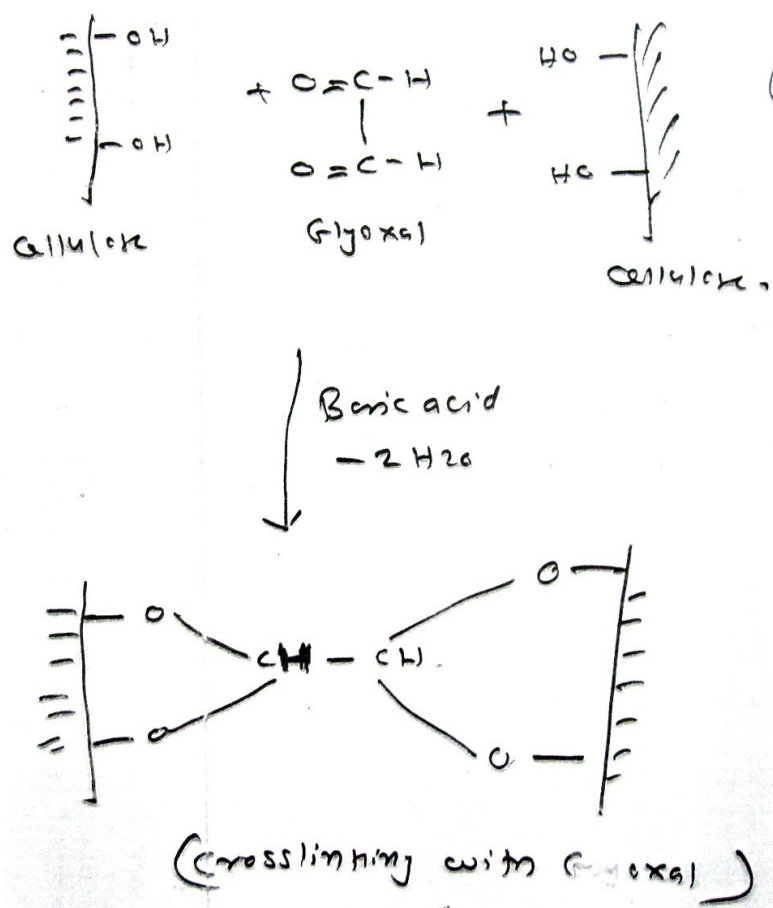
Glyoxal:

It can also be used directly as formaldehyde free cross linking agent.

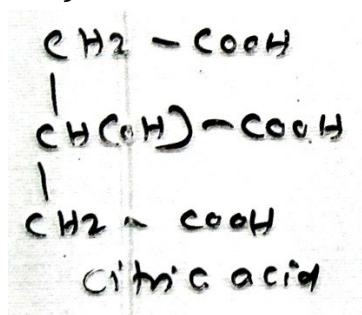
Limitations:

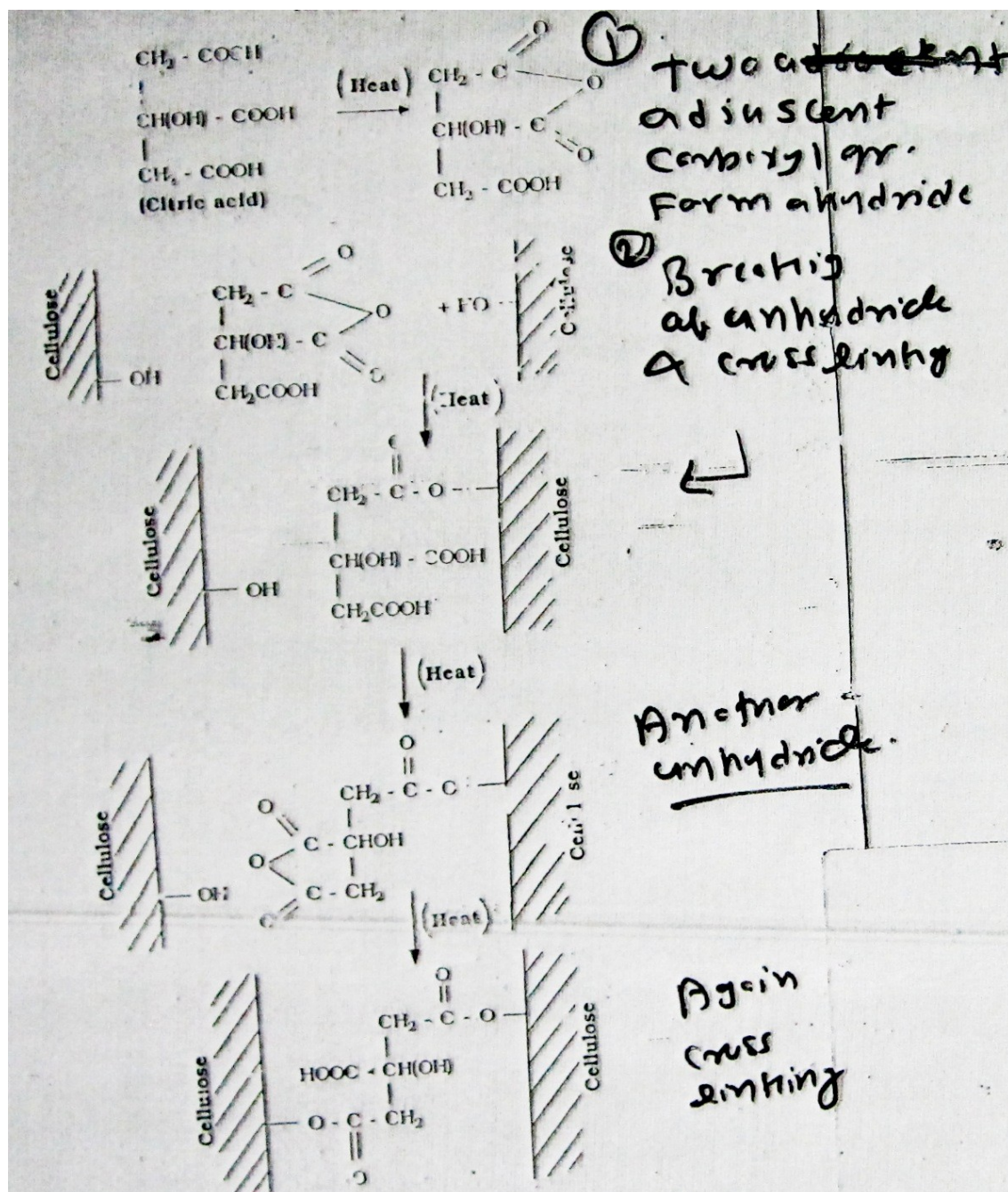
50% is wasted without cross linking leading to poor crease recovery.





Citric Acid (Tricarboxylic acid)

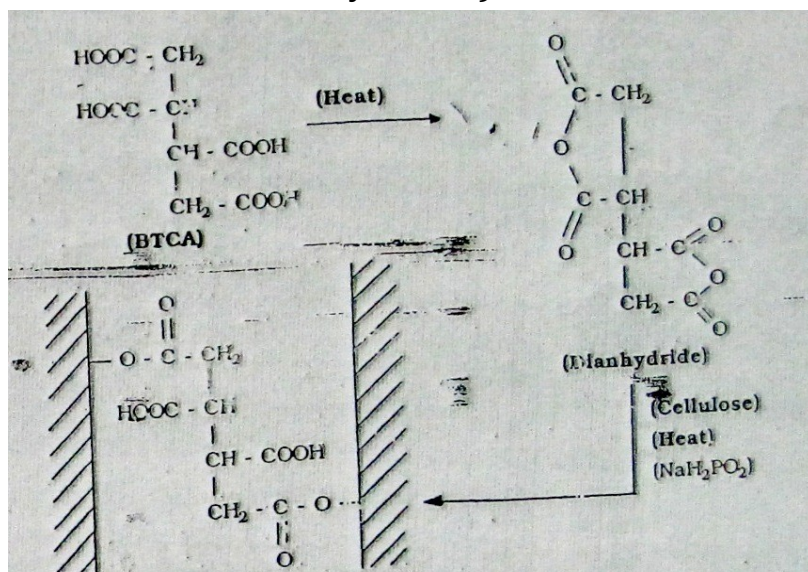




Problems in Citric Acid:

- Yellowing of fabric.
- Excessive Strength loss.

BTCA (1,2,3,4 Butane tetra carboxylic acid)



- BTCA is applied 4-5% OWF.
- Catalyst used is Sodium hypophospite.

Limitations of BTCA:

- Expensive.
- Large amount of catalyst Sodium hypophosphite required which is also expensive.
- The catalyst is strong reducing agent and discolors some reactive dyes.

BIOPOLISING:

- It improves appearance of cotton and other natural fibres by enzymatic treatment.
- The main advantage is prevention of pilling.

Enzyme used is cellulase.

Mechanism:

Enzyme cellulase hydrolyze the micro fibrils (hairs or pills) protruding from the surface of yarn as they are most susceptible to enzymatic attacks.

Effects:

- Fabric has low pilling tendency.
- Softer and smoother feel.
- Superior brightness.
- Unlike conventional softeners, it imparts wash proof and non greasy softening effect.
- Fabric looks new after repeated washing.

Fabric for biopolishing:

- Cotton fabric its optional → For Value addition only.
- It is must for lyocell fabrics, as it has tendency to fibrillate easily when wet.

What is lyocell fibre?

Dissolution of cellulose fibre in form of wood pulp or recycled paper in a solvent 'amine oxide'

- The solvent is recycled.
- Ecofriendly process of manufacturing.
- Very strong when wet unlike viscose.
- High Degree of Polymerization (DP).
- Short process compared to Viscose.

Process of Biopolishing:

Biopolishing is generally carried out in Jet or Garment dyeing m/c.

Cellulose enzyme	1-2%
pH	4.5-6
Temperature	50-60°C
Time	1 hour

Liquor ratio should be enough to have enough agitation.

Weight loss 3-5%

PLASMA TECHNOLOGY IN TEXTILE PROCESSING**What is Plasma?**

- Highly reactive material used to modify the surface of the substrate. i.e. Plasma activation or modification.
- It is a substance, usually a gas whose atoms have one or more electrons detached and hence ionized.
- Overall neutral as it consists of equal no of -ve & +ve ions called plasma.

How plasma is produced?

- 1) By providing heat to gas (high temperature) or when kinetic energy of gas particles rises equal to ionization energy of gas.
E.g. Atmosphere of most stars, gases on the upper atmosphere of earth (about 400km) gas within the glass tubing of Neon advertising signs.
- 2) To pass high energy electrons to low pressure gas. The individually charged plasma particles can be controlled by electric or magnetic field.
- 3) By applying electric field to low pressure gas.

Plasma processing:

- High density plasma not suitable for textile applications.
- Plasma density depends on temperature and magnetic field applied.

How plasma works on textiles?

- It is only a surface reaction.
- Modifies the surface in nm range (100nm)
- Coat the fibre with nm thin film depending on gas used. This technique can be used to make fibre.

- Hydrophilic properties can be imparted by oxygen plasma.
- Hydrophobic properties can be imparted by Hexafloroethane plasma.
- Improve colour fastness.
- Improve dyeing rates.
- Improve shrinkage resistance.
- Reduce inflammability.
- Improved pigment fixation.
- Flouing plasma for medical textiles.
- Anti felting on wool.
- To facilitate the removal of size & contaminants

CHAPTER 5: ENVIRONMENTAL MANAGEMENT:

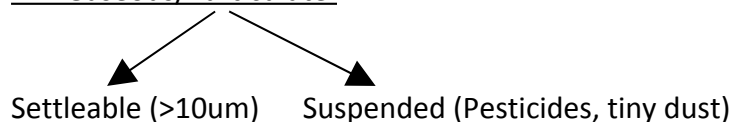
All the biotic and abiotic factors that act on organism and influence its survival is called environment.

Pollution: Any undesirable change in the physical, chemical or biological characteristic of natural water, air or soil which affects the life of living organism is called pollution.

TYPES OF POLLUTIONS

- 1) Air
- 2) Water
- 3) Soil
- 4) Radioactive pollution
- 5) Noise pollution

1) Air- Gaseous/Particulate:



2) Water:

- a) Thermal – Sudden rise in temperature of water.
- b) Underground water pollution due to seepage from industrial waste
- c) Marine pollution: Oil spills, polluted rivers.

3) Soil Pollution:

Increase in use of fertilizers, pesticides

- Sanitation of soil Increase in concentration of soluble salts
- Excessive use of alkaline fertilizers e.g. Sodium nitrate.

4) Radioactive Pollution:

- Radioactivity: Property of certain elements (radium, uranium) to emit α particles, (Protons), β particles (electrons) and gamma rays by disintegration of nuclei.

Sources:

- Atomic explosion/atomic weapons.
- Mining of plutonium & thorium.
- Reactors and nuclear fuels
- Radiation therapy.

5) Noise Pollution:

- Industry, transport etc.

SUMMARY OF PROCESS WASTES

Starch PVA CMC	Small	High BOD 35% of total BOD- 1000ml/L COD-1000ml/L
Caustic Soda, Waxes, Other natural impurities, Surfactants, Suspended/Dissolved solids	High 30% of total volume	High pH, High COD of 30% (19000), BOD-3000
Caustic soda Cl ₂ , H ₂ O ₂	Mostly washing	High pH 9-10, 5% of BOD
Cautic soda	Small	High alkalinity, Low BOD 100 & COD 200
Various dyes & Chemicals	Large	Strongly Coloured, High BOD of 800, COD of 1400.
Dyes, Starch, gums, oils	Small	Highly coloured, BOD of 1400, COD of 4000
Starch & Various finishing agents	Small	Low BOD

SOLID WASTE MANAGEMENT

Definition of waste: Any substance that is discarded is called waste.

Two types of waste are

1. Urban e.g. Garbage, kitchen waste, plastic, paper etc.
2. Industrial waste e.g. Furnace slog, Coal ash, metal scraps, used batteries.

Classification of waste (General waste categorization)

Biodegradable waste: The waste can be degraded by microorganism

E.g. Vegetable peeling, discarded food, crop/farm residue.

Non biodegradable waste: cannot be degraded by microorganism.

E.g. Polyethene bags, scrap metals, glass bottles, plastic, metal cans.

1. Toxic waste:
It is poisonous.
E.g. Pesticides, acids, alkalis, radioactive substance.
2. Non toxic waste:
E.g. Glass, paper, wood, scrap, leather, rubber.

3. Biodegradable waste:
Waste released by hospitals & clinics.
e.g. Cotton, syringes, plastic bottle.

EFFECTIVE POLLUTION PREVENTION PROGRAMME

3 R Principle (Reduce, Reuse & Recycle)

1) Reduce:

Prevention/Reduction of waste material being created.

E.g. Eco friendly processing, avoidance of reprocessing, first time right approach.

Reuse:

E.g. Reuse of caustic from mercerization, reuse of cooling water/energy, use of paper bags/cotton packing instead of nylon packing.

Recycle:

E.g. PVC, PP are recyclable, Broken cones in winding can be recycled, electronics equipment are difficult to recycle due to dismantling.

2) Promote the use of ecofriendly substances and reduce generation of green house gases:

E.g. Use of non formaldehyde resins use of ecofriendly fuels in boilers, use of formic acid in place of acetic acid.

3) Conserve natural resources and use less water:

- Low liquor dyeing/continuous ranges.
- Recycling of cooling water.
- Recycling of waste energy.
- Use of counter current system of washing.
- Use of enzymes
- Use of synthetic detergents in place of soaps.

4) Process modifications

- Hot mercerization
- Combined scouring and bleaching.

5) Substitution of less toxic material

- Ecofriendly resin finishing.
- Banned azo dyes.

6) Improved housekeeping

Japanese method of housekeeping '5S' Improved housekeeping

Gives

- ❖ Better reproducibility.
- ❖ Improved quality.
- ❖ High moral of staff.
- ❖ Less reprocessing.

7) Awareness and training

Create awareness how pollution prevention saves money and protect health.

8) Separation of effluent:

Separate effluent of less BOD/COD which can be recycled easily.

9) Integrated pollution prevention practice through government services/acts/policies.

10) ISO 14000 implementation.

11) Improved maintenance culture of machinery

- It improves reproducibility.
- Reduces reprocessing.

12) Extended producer responsibility (EPR)(New concepts)

This is a new law in developed countries. As per this law the firm which manufactures product has responsibility of the products throughout their useful life.

13) Fabric with ecolables garments

These labels are for garments which are produced completely by ecoprocessing and buyers are prepared to pay extra price of ecolables garments.

MEASUREMENT OF BOD

BOD:

Amount of oxygen used by aerobic bacteria to decompose organic material. This process may take place many days hence to standardize the measurement of BOD following standards are taken.

Time (Incubation period): 5 days.

Temperature: 20°C

Method:

- 1) Take pure distilled water saturated with oxygen (Dissolved oxygen)
- 2) Take 5ml of polluted water + 25ml of pure water from 1 in BOD bottles.
- 3) Keep pure water and dilute impure water for 5 days at 30°C.
- 4) Measure Dissolved oxygen of pure water and dilute impure water after 5 days.
- 5) The difference in Dissolved oxygen of two reading will give BOD.

MEASUREMENT OF COD

Any kind of chemically oxidizable impurities present in effluent is COD.

It is measure of both biologically oxidisable and biologically inert organic matter.

Principle of measuring COD

Most organic matters are completely oxidized by boiling mixture of chromic acid and H_2SO_4 to produce CO_2 & H_2O .

Hence measured quantity of effluent sample and distilled water is refluxed separately with excess amount of $K_2Cr_2O_7$ and H_2SO_4 , in presence of oxidizing catalyst.

The balance amount of $K_2Cr_2O_7$ in both solutions are measured by titrating with ferrous ammonium sulphate (FAS) using ferroin as indicator. The difference in two reading will give COD.

Procedure:

- 1) Take 20 ml effluent sample in 250 ml reflux flask.
- 2) Add 5 gm $HgSO_4$ as catalyst.
- 3) Add 30ml H_2SO_4 .
- 4) Add 10 ml 0.25N $K_2Cr_2O_7$.
- 5) Reflux for 2 hours.
- 6) Cool and add 80 ml distilled water.
- 7) Add 2-3 drops ferroin indicator and titrate against 0.1N FAS (Cool change bluish green → Wine red)
- 8) Take reading on V1
- 9) Repeat experiment with pure distilled water and 2nd reading as V2.
- 10) COD of effluent sample is $V2-V1$. (The blank experiment takes care of any thermal decomposition of $K_2Cr_2O_7$)

TOTAL SOLIDS IN EFFLUENT

This consists of both dissolved + suspended solids.

Measurement of total solids:

- 1) Weigh china clay dish (W1).
- 2) Pipette 50ml of well mixed sample into dish.
- 3) Evaporate the sample to dryness.
- 4) Transfer dish to desiccator till it attain room temperature.
- 5) Weigh the dish again (W2)
- 6) $W2-W1$ = Total solids.

TOTAL DISSOLVED SOLIDS (TDS)

Limit- 2100mg/l

Procedure:

- 1) Take a measured quantity of effluent sample.
- 2) Filter into a dish which is weighed before (W1).
- 3) Boil and evaporate the water.
- 4) Weigh the dish with residue (W2).
- 5) $W2-W1$ = Total dissolved solids.

E.g. salts in effluent.

Limits:

300 mg/l

Examples: Biological solids like algae cells, Short/long fibers, yarns etc.

Measurement:

- a) Find out total solids (TS)
- b) Find out total dissolved solids (TDS)
- c) Suspended solids = TS-TDS

Suspended solids if enters in lakes can reduce dissolved oxygen (DO) as entry of sunlight in water is restricted preventing photosynthesis of aquatic plants.

TURBIDITY:

Definition:

It is a measure of the extent to which light is either absorbed or scattered by suspended material in water.

Turbidity Vs Suspended Solids:

Adsorption and scattering are influenced by both size and surface characteristics of suspended material.

Hence turbidity is not direct measurement of suspended solids.

E.g. one small suspended solid may not cause turbidity but if it is crushed in thousands of particles of colloidal size, it will create turbidity even though mass of solids (suspended) is not changed.

Turbidity test is generally carried out on drinking water as small amount of impurities can even be unhealthy.

Measurement:

The instrument used is JACKSON turbidity meter.

- It consists of long tube and standardize candle. The candle is placed beneath the glass tube.
- Glass tube is housed in black metal box so that light from candle only can be seen.

Procedure:

- The turbid water sample is poured slowly into glass tube until the lighted candle is no longer visible.
- The glass tube is calibrated with readings for suspension of silica dioxide (SiO_2) with one Jackson turbidity unit (JTU) equal to turbidity produced by 1mg of SiO_2 in 1 liter of distilled water.

MEASUREMENT OF GREASE & OIL

Principle:

Grease and oil are soluble in Diethyl ether ($\text{C}_2\text{H}_5\text{-O-C}_2\text{H}_5$)

Procedure:

1. Take 50ml effluent water and 20ml ether in separating funnel.
2. Stir for 30 minutes.
3. Grease and oil will dissolve in ether which will float on top of separating funnel.
4. Transfer the top portion of ether into evaporating dish.
5. Evaporate ether at 30-35°C.
6. Weigh the residue of oil and grease.

CHAPTER 6: EFFLUENT TREATMENT

PRIMARY TREATMENTS

1. Screening
2. Sedimentation
3. Equalization
4. Neutralization
5. Coagulation
6. Flotation

Screening:

- a) It is the first stage of treatment.
- b) Two types of screens used.
- c) Coarse screens consist of heavy wire spaced at 25 to 50mm apart at an angle of 60° to effluent flow. It removes suspended and floating material such as fibres, yarn, cloth pieces.
- d) Fine screen is a woven wire with size of opening between 0.8 to 6mm. It removes any short fibres passed out through coarse screen.

Sedimentation:

It is settlement of solids by gravity. It is generally not carried out because most of effluent requires chemical coagulation.

Equalization:

In this process mixing of effluent from various drains and its equalization for 6-10 hours is done.

Purpose of equalization

- Textile mill produce different type of effluent having different BOD, COD, pH etc in different process.
- Effluent plant will work efficiently only if BOD and all other loads are kept constant throughout day/week.

How equalization is done?

Different streams of effluent are allowed to hold in holding tank for a specified period so that character of effluent is uniform. Equalization means stabilization of pH and BOD/COD load.

Equalization helps in

- a) Prevention of shock loads in secondary treatment.
- b) It reduces cost of effluent by self neutralization of acidic and basic streams.

In this process some of the strong waste are segregated and kept in separate holding tank. They are released gradually at a uniform rate in equalization tank over a long time to attain uniformity. If such strong waste will enter equalization tank suddenly it will upset further treatment.

The mere holding will not produce equalization effect. Hence it is assisted by

- Mechanical agitation.
- Aeration.

Neutralization

Textile effluent possesses extreme pH value. Neutralization and pH correction is necessary for subsequent treatment like coagulation.

For coagulation with Alum pH 8-9

For coagulation with Ferrous sulphate pH 9-9.5

For biological treatment pH 6-9

Depending on pH of effluent in equalization tank dosing of mineral acid or lime solution is made to get desired pH.

Neutralization of acid wastes

a) With Lime:

Advantage: Very cheap

Disadvantage: Slower reaction rate and hence more time for completion of reaction.

Lime is used when large quantity of effluent is to be treated.

b) With caustic soda:

Advantage: Most effective and very fast.

Products of neutralization are highly soluble in water.

It does not increase the hardness.

Disadvantage: Expensive, hence recommended for smaller plants.

Neutralization of Alkaline waste:

a) With Sulphuric acid:

Advantage: Highly efficient.

Disadvantage: Handling problem

b) Utilizing boiler flue gas: CO_2 is present in good quantity in boiler flue gases. It reacts with alkalinity to form carbonates.

Coagulation

Very effective for removal of colour and suspended matter like starches and gums.

Coagulants used: Alum, Ferrous sulphate, Ferric chloride.

Coagulant acids: Like polyelectrolyte (High molecular weight polymers) or activated silica help the process of coagulation.

Quantity to be added: About 30-100mg/l. The quantity is predetermined in laboratory.

Optimum conditions: Most coagulants work well under acidic conditions.

Aluminium coagulates at pH 5.5 to 6.8

Iron coagulates at pH 5.5 and 8

Operation sequence for coagulation:

1) Flash Mixing:

Add coagulants, aids with pH adjusting chemicals in 2-3 minutes.

2) Flocculation:

In this process paddles gently stir the waste liquor for 30 minutes to form flock.

Definition of Flocculation:

It is a process of gentle and continuous stirring of coagulated water for the purpose of forming flocks through the aggregation of minute particles due to collision.

3) Settling:

Allowing the formed flock to settle.

1, 2, 3 are carried out in separate units.

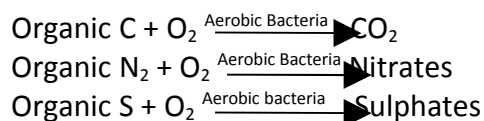
BOD, COD load is almost reduced by 60% in coagulation process.

Flotation

This is done to remove fine suspended solids that cannot be settled by any means. In this method application of air in form of bubbles which carries the suspended particles to liquid surface where they are readily removed by shimmers.

SECONDARY TREATMENTS (BIOLOGICAL TREATMENT)

Primary treatment removes the colour and suspended matter to some extent. Secondary biological treatment removes dissolved organic matter, reducing BOD to very high extent in effluent. The bacteria can decompose many of organic matter.



Activated Sludge Process

What is activated sludge?

This is biomass produced in effluent by the growth of microorganisms in aeration tank in presence of dissolved oxygen. The term activated comes from the fact that sludge is rich of bacteria and many other living organisms which can be fed on organic matter in incoming effluent.

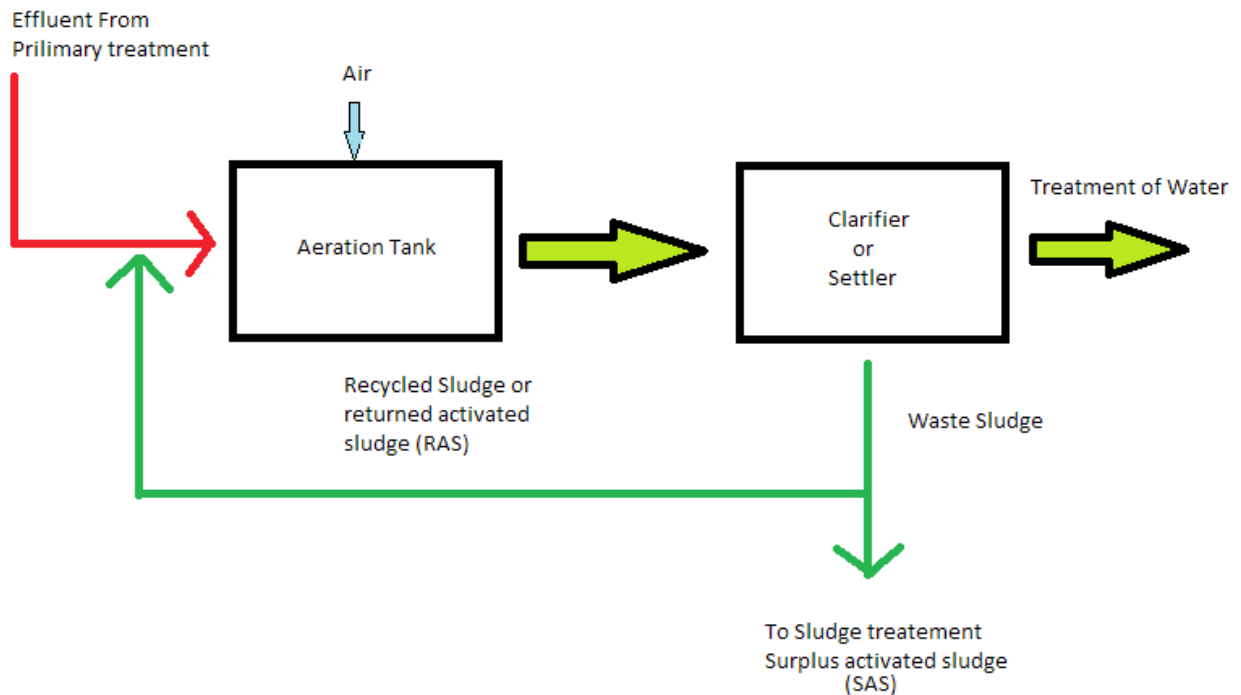
Major constituent of activated sludge is bacteria along with small fungi and protozoan's.

Bacteria ——— Heterotrophic is major constituent and breaths organic matter.

Autotrophic is present in small constituent and breath inorganic matter.

The principal of activated sludge process.

- 1) The effluent is first mixed with air in aeration tank to decompose the organic matter by microorganism.
- 2) This effluent enters the clarifier or settler where activated sludge is settled.
- 3) The part of this activated sludge is returned to aeration tank for treatment of fresh effluent.



The sequence of operations in Activated sludge process

- 1) Aeration of effluent
 - i) Diffused Aeration
Effluent liquor is run into deep tanks where air is pumped at bottom through blocks in form of bubbles (Just like fish tank). These bubbles also cause stirring action. Strong effluent oxygen may be used in place of air. The compressors are used to blow the air.
 - ii) Mechanical Agitation:
It creates turbulence on the air liquid interface which helps air to enter effluent E.g. High speed impellers.
In the aeration tank the effluent is mixed with port of activated sludge. The bacteria consume dissolved organic matter as food to live, grow and multiply.

In aeration Tank:

Heterotrophic bacteria are in major quantity and derive their food from organic matter.

Protozoa: Their food is bacteria itself and particulate matter. They are present in small quantity. Protozoa are useful biological indicator of the condition of activated sludge. They are excellent indicator of aerobic conditions. They are also indicator of toxic substance in effluent as they are more sensitive to toxic substance than bacteria.

Fungi: In small quantity can break ammonium compounds to nitrate.

Clarifier or Settler

When effluent is oxidized for 1-2 days the organic matter is broken down by microbes. This effluent is now collected in clarifier or settler. Hence activated sludge is settled in 1-2 hours. Part of sludge is returned to aeration tank (RAS) i.e. Returned activated sludge and remaining is sent for their treatment and disposal (SAS) i.e. Surplus activated sludge.

High quality effluent	High cost
Reduction of 90% BOD	Sensitive to shock load
	Sensitive to toxic waste
	The success depends on mixed community of microbes present that will consume variety of organic wastes.

TERITARY TREATMENT METHODS

Multi media filtration:

- It uses coarse to fine filtration for removal of suspended solids.
E.g. Combination of coal and sand along with other material.
- They allow distribution of suspended material throughout the media rather than at surface.
- The filtration units based on conventional gravity type.

Reverse osmosis

Definition of osmosis:

When two solutions of different concentration are separated by semi permeable membrane, water flow from solution of lower concentration to solution of higher concentration.

E.g. Process happening in nature: Dry fruits, fish, plants leaves.

Definition of Reverse osmosis:

If water to be purified is placed in a chamber with a semi permeable membrane, and pressure more than osmotic pressure is applied, water molecules pass through the membrane but no solute molecules passes through the membrane. (Opposite to that of osmosis)

Activated Carbon Adsorption

Definition of activated carbon:

A form of carbon that has been processed to make it extremely porous and then have large surface area available for adsorption.

Principle:

- I. Activated sludge process reduced BOD by 90-95% but COD is not reduced.
- II. Activated carbon process can remove many finishing chemicals and dyes reducing COD.
- III. Capital cost, operational cost and maintenance cost is cheaper than reverse osmosis.
- IV. Sometimes effluent after primary treatment is directly subjected to activated carbon process without biological treatment (activated sludge process)

Process:

- I. Effluent is passed over a bed of activated carbon.
- II. The chemical molecules come in contact with surface of carbon and are held there by weak vanderwall's forces.
- III. Treatment efficiency is affected if a suspended solid exceeds 50mg/l which is collected in carbon bed. Hence before passing through carbon bed the suspended solids should be less than 50mg/l.
- IV. The surface are of activated carbon is about $1000\text{m}^2/\text{g}$. The poor structure and high surface area is very important.

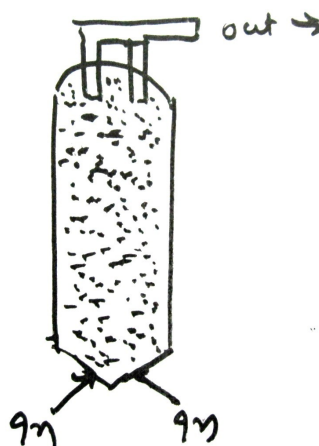
Manufacturing of activated Carbon:

They are manufactured from wide variety of carbonaceous materials like wool, coal, lignite, peat, lignin, bagasse, saw, dust, petroleum residues by heating at very high temperature.

Operating systems:

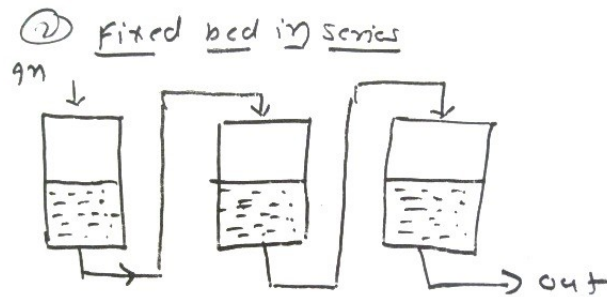
- 1) Moving beds
- 2) Fixed bed in series.
- 3) Fixed bed in parallel.

1) Moving Beds:



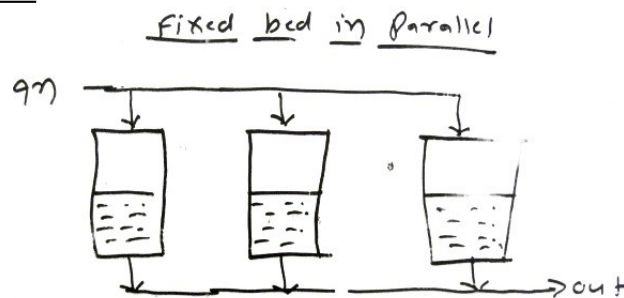
- I. Water flows from bottom through the bed and leaves on top (Counter current)
- II. Exhausted carbon is removed from bottom and fresh added at top.
- III. Good for small effluent plant.

2) Fixed bed in series:



- I. Maximum utilization of activated carbon.
- II. Good for treating high volume of effluent.
- III. It can handle suspended solids to some extent.
- IV. High capital cost.
- V. Cleaning by backwashing.

3) Fixed bed in parallel.



- I. More efficient than moving beds but less efficient than fixed bed in series.
- II. Good for medium volume of effluent.
- III. High cost.
- IV. Cleaning by back washing.

Reactivation of Carbon:

- I. Reactivation is done thermally.
- II. High capital cost.
- III. Certain firms have established business of reactivating and selling activated carbon in USA.
- IV. Common reactivated plant by processors.

Problems associated with activated carbon:

- I. Wet carbon in contact with metal, induces corrosion. Hence entire system should be constructed with corrosion resistant metal. Mild steel cannot be used.

Removal of exhausted carbon:

- I. It is removed by hydraulic system and transported to activation plant in form of slurry.
- II. Flush points are provided to remove all carbon.

SLUDGE TREATMENT & DISPOSAL

- I. Treatment & disposal of sludge is a complex and important job as it may contain many objectionable materials.
- II. 40% of total effluent cost is for sludge disposal.

Characteristic of sludge:

- I. Sludge contains 90-95% of effluent BOD.
- II. It becomes anaerobic within few hours and must be isolated to prevent nuisance problem.

a) Sludge Treatment

The first stage of sludge treatment is sludge thickening to reduce its volume.

It is impossible to handle the sludge without thickening. The volume of sludge is reduced by 50% by this process.

Sludge thickening can be done by:

- a) Gravity thickening
- b) Dissolved air flotation.

a) Gravity thickening:

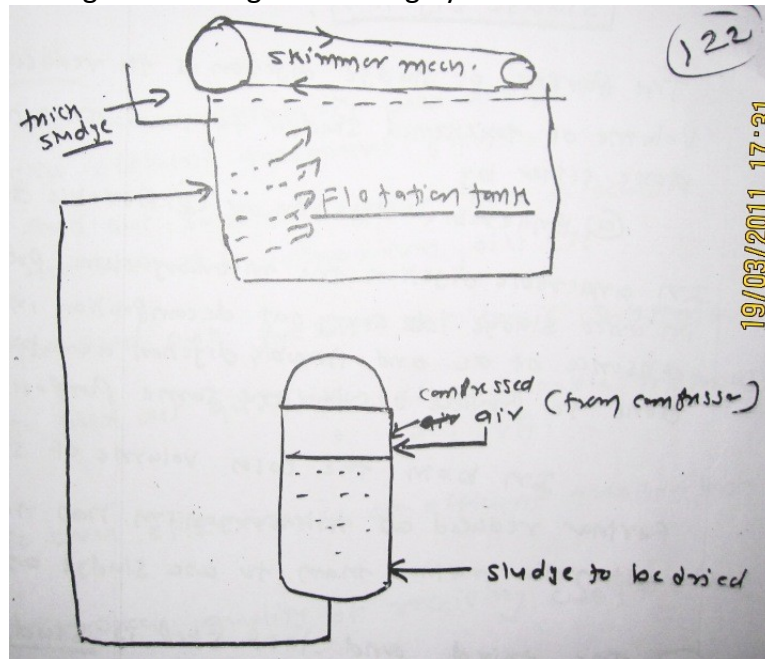
- It consists of a circular tank similar to sedimentation tank with conical shape at bottom.
- The sludge is allowed to enter this tank which is provided with vertical pickets (stirrer) to stir the sludge gently.
- This stirring action opens up channels of water and sludge settles down and is withdrawn from conical bottom.
- The supernatant water is returned to primary settling tank.

Limitation: It is a slow process.

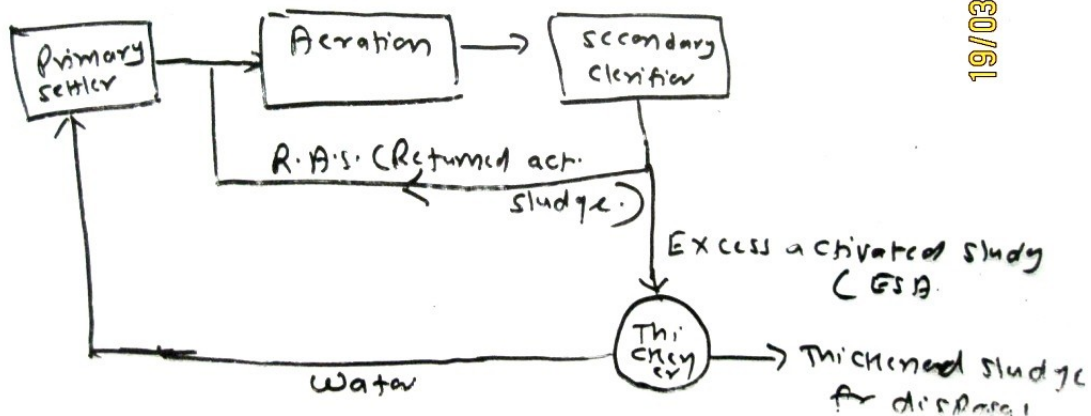
b) Dissolved air flotation technique

- I. In this process a small quantity of effluent is subjected to aeration under pressure of 60 lb/in².
- II. This pressurized effluent is released at bottom of tank and depressurized to atmospheric pressure.
- III. The air is released in form of very small bubbles that entraps the sludge particles, carrying them at top.
- IV. The thickened sludge is skimmed off from the top of tank, while the water is removed at bottom.

Below is schematic diagram of Sludge thickening by dissolved air floatation.



The mechanism of Activated sludge + Sludge thickening



b) Sludge Digestion (The second step in sludge treatment)

The purpose of sludge digestion is to reduce the volume of thickened sludge further. This can be done either by

- Anaerobic digestion
- Aerobic digestion

In anaerobic digestion the microorganism present in dried sludge carry out decomposition in absence of O_2 and in aerobic digestion aeration is done to provide O_2 for the same purpose.

In both the cases volume of sludge is further reduced as microorganism has no alternative rather than to use sludge as food.

c) Sludge Disposal

The third and last step is sludge disposal. Lastly the sludge which is dried and digested has to be disposed off. Following methods are commonly used for disposal.

I. Incineration:

The sludge is burnt with proper use of fuel, inside a furnace.

II. Land application of Land filling:

- For soil conditioner
- The nutrient value may be sometimes used for farming.

ANALYSIS OF EFFLUENT

Purpose:

- To find out treatability and design an effective effluent treatment plant.
- To find out substance that causes difficulties in treatment e.g. Chromium, oils etc.
- To find out presence of toxic substances.
- To find out quantities of recoverable material. E.g. PVA
- To check effectiveness of effluent treatment plant.
- To check quality of receiving water.

Collection of waste water sample

- There is serious variation in textile effluent as regards to flow and composition.
- Sample collected should be true representation of effluent.
- Hence collect samples at uniform interval of 30 minutes each for 24 hours.
- Volume of sample collected should be proportional to flow.
- Before collection container should be rinsed with effluent.

Recording of results:

- Results should be expressed in terms of mg/l or PPM.
- Following information should be recorded.
 - Effluent stream (Mention the process)
 - Time of collection.
 - Rate of flow at the time of collection.
 - Total volume of effluent released in the process.
 - Collected by and his/her sign.

Parameters to be determined

Desizing	Colour, odour, temperature, BOD, surfactants
Kier Boiling	Colour, odour, temperature, pH, alkalinity, BOD, Suspended solids, COD
Bleaching	Colour, odour, temperature, pH, residual Chlorine, suspended solids.
Mercerization	Colour, odour, temperature, pH, BOD, Suspended solids
Dyeing	Colour, odour, temperature, pH, Suspended solids, TDS, salts, BOD, COD, toxic substaces.
Printing	Colour, odour, temperature, pH, Suspended solids, TDS, BOD, COD, surfactants, oils etc.

RECOVERY AND REUSE OF WASTE WATER**Water uses in textile industry**

Steam generation	6%
Cooling water	7%
Process water	75%
Sanitary use	6%
Miscellaneous	6%

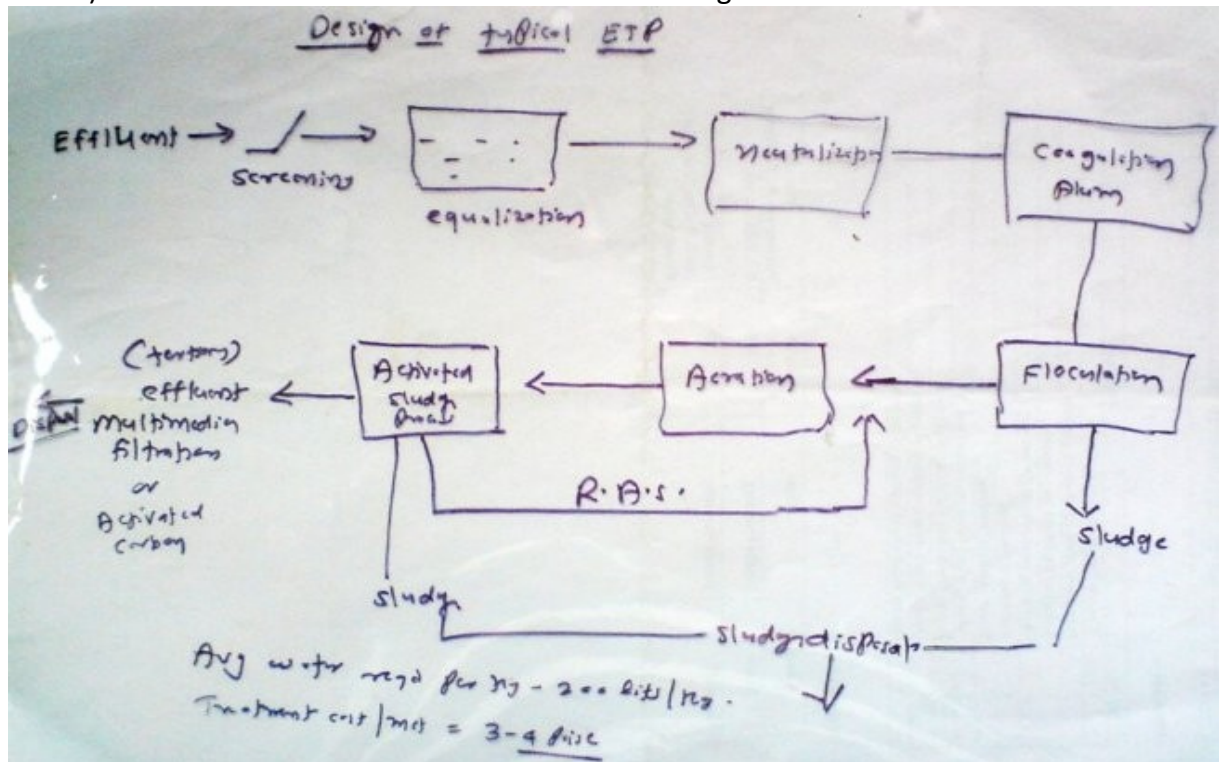
Purpose of water use & recycle.

- 1) Reducing of processing cost.
- 2) Less loads on effluent.
- 3) Reduction in thermal energy.

Methods:

- 1) Mercerization
Caustic recovery. The rinse water from mercerization can be used for scouring.
- 2) Reusing of cooling water:
It has temperature of 50-60°C and can be used for washing and disperse dyeing.
- 3) Counter current in washing range:
For continuous ranges clean water enters the final wash box and flows counter to the movement of fabric.
- 4) Use of low liquor dyeing machine like air flow.
- 5) Reuse of dyeing bath.
- 6) Use of enzymes-requires less water for washing.
- 7) Use of catalase enzymes for peroxide bath clean up.
- 8) High temperature discharge in polyester fibre/yarn dyeing.
- 9) Combined scouring + bleaching.
- 10) Dyeing program Management:
Dye light shades first, followed by medium & dark shades.
- 11) Good housekeeping:
Stop leakages of steam and water, installation of water meters turn of cooling when machine is stopped.

- 12) Recovery of dyes by reverse osmosis and recycling of water.
- 13) Reuse of final rinse water in next lot for washing.



CHAPTER 7a: NOISE POLLUTION IN TEXTILE INDUSTRY

Definition of sound:

Sound is mechanical energy wave propagation. Sound requires medium to travel like air and it travels by compression and rarefaction.



Audible frequency of sound is 20Hz to 20KHz, >20KHz is ultrasound.

Noise pollution: Noise pollution can be defined as unwanted sound dumped into environment which causes adverse effects living organism.

Measurement of sound: Intensity of sound is measured in decibel (dB). The intensity in dB(decibel) tells us about loudness of sound.

Decibel: It is the just noticeable Difference (JND) in sound intensity.

Some noise sources and their intensity in Db

Threshold of normal hearing	0
Normal breathing	10
Whispering	30
Normal conversation	50-60
Automobile noise	70
Aircrafts at take off point	150
Aircraft at 300m height	100

$$\text{Decible} = 10 \log \frac{I_{\text{Source}}}{I_0}$$

I_{Source} = Intensity of source whose sound is to be measured.

I_0 = Intensity of threshold of hearing

$I_0 = 10^{-12}$ watts/m² at 1000Hz

[log 1 = 0, log 2 = 0.3, log10 = 1, log100 = 2]

EFFECT OF NOISE POLLUTION

Anybody exposed to sound level about 85dB for long time may permanently loose his hearing ability.

In addition side effect like below are seen in the affected persons

- I. Sleep disorder.
- II. Mental fatigue and emotional disturbances.
- III. Annoyance.

- IV. Reduces alertness.
- V. High blood pressure.
- VI. High pulse rate (high heart beat)
- VII. Frequent headaches.
- VIII. Lowering of concentration.
- IX. Muscular strain.

Noise pollution level & its harmful effects.

No effect
Stress, tension, psychological problems
High B.P, disturbed sleep
Ear diseases or permanent hearing loss.

Permissible noise exposure to industrial workers.

Exposure time (in hours/day)	Limit dB
8	60
4	93
1	96
1/2	102
1/8	108
1/16	111
2minutes	114

NOISE POLLUTION & TEXTILE INDUSTRY

Sources:

1) Spinning and weaving department contribute maximum to noise pollution.

Department	dB
Blow room	85dB
Ring frame	100dB
Doubling	90dB
Loom shed	102dB
Finishing	80dB

National institute of occupational health (NIOH) study shows that average noise pollution in textile industry is 102-110dB.

Reasons for sound in textile industry.

- a) Noise from gear wheels.
- b) High speed twistors.
- c) High speed looms.
- d) Compressors for air jet.

- e) Generators.

Modern technology has reduced the work of worker but increased the sound pollution.

CONTROL OF NOISE POLLUTION

- 1) Control at receivers end:
Use of ear protectors like earplugs, noise helmets etc.
- 2) Suppression of noise at source:
 - i) Proper designing & replacing metal parts with nylon
 - ii) Proper lubrication.
 - iii) Proper maintenance by
 - Replacement of worn parts.
 - Proper alignment.
 - Tightening of loose parts.
 - Providing vibration insulators to prevent transmission of sound through base.
 - iv) Installing noisy machines in sound proof chambers e.g. soundproof generators.
 - v) Use of Silencers.
- 3) Acoustic zone:
Increase distance between and source and receivers.
Silence zone- Residential areas/ hospitals.
- 4) Sound insulation:
Construction of windows with double or triple panes of glass.
- 5) Planting of trees:
Along roads near hospitals, residential colonies.
- 6) Legislative measures & laws for
 - i) Use of loudspeakers.
 - ii) No horn zone for vehicles.
 - iii) Forming separate laws to prevent pollution of noise.

CHAPTER 7b: AIR POLLUTION IN TEXTILE INDUSTRY

Definition of air pollution:

Introduction of chemical, particulate matter or a biological material that causes the harm or discomfort to humans or other living organism or damages the natural environment.

CLASSIFICATION OF AIR POLLUTANTS

- 1) Classification based on origin.
 - a) Primary pollutants:
They are directly emitted from known sources e.g. CO₂, SO₂.
 - b) Secondary pollutants:
They are not emitted directly. They are formed by interaction of primary pollutants. E.g. Ground level ozone, Photochemical smog, Acid rain.
- 2) Classification based on state of Matter
E.g. Gaseous-CO₂, SO₂
Or
Particulate e.g. Dust particles, smoke, pathogenic microbes.
- 3) Classification based on chemical composition
E.g. Inorganic- CO, CO₂, NO₂
Organic- Hydrocarbons, aldehydes.

SOURCES OF AIR POLLUTION

Manmade sources of air pollution

- 1) Stationary sources such as smoke from thermal power plants, factories.
- 2) Mobile sources like motor vehicles, aircrafts.
- 3) Waste deposition in landfill, which generates methane.
- 4) Central burn practices in agriculture.
- 5) Nuclear weapons.
- 6) Burning of LPG, kerosene for domestic use.

Natural sources of air pollution

- 1) Dust, storms.
- 2) Methane emitted by digestion of food by animals.
- 3) Smoke and CO from wild fire.
- 4) Volcanic eruption which produces sulphur, chlorine and ash particulate.

THE EFFECTS OF AIR POLLUTION CAN BE CLASIFIED AS

- 1) Global effect.
- 2) Effect on human being.

- 3) Effect on plants.
- 4) Effect on nonliving things.

Global effects of air pollution

- 1) Global warming or Green house effect:

What are green house gases?

They are CO₂, Methane, Nitrous oxide.

These green house gases contribute upto 1% in earth atmosphere and it is required to keep earth warm.

However industrialization, deforestation burning of fossil fuels has increased the % of green house gases in atmosphere.

In last century the average temperature of earth has increased by 1°C.

The IPCC report says that in 21st century the earth temperature will further increase by 2-4°F.

The green house gases absorb the IR radiations of sunlight reflected back by earth surface causing rise in temperature.

The global warming will lead to

- Rise in sea level
- Melting of glaciers.
- Extinguish many living species.

- 2) Ozone layer depletion:

Chlorofluorocarbons (CFC) emitted by human activities has carried out catalytic destruction of ozone layer allowing harmful ultraviolet (UV) rays to enter earth's atmosphere.

Exposure to UV radiations may cause skin cancer.

- 3) Acid rain:

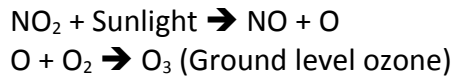
The primary cause of acid rain are CO₂, Sulphur dioxide and nitrogen oxide, released by industrial activity. These gases when emitted in high concentration return to earth with rain making rainwater acidic with pH 4.5.

Effects of acid rain:

- a) It acidifies fresh water and aquatic life cannot live under acidic conditions.
- b) Damages the trees and plants as trees directly get damaged with SO₂ and acidic rain also cause damage to nutrients in soil.
- c) Damage to building and materials as SO₂ plays main role in it. E.g. Taj Mahal.

- 4) Photochemical smog:

Smog is a combination of various pollutant gases with water vapor and dust. Smog is nothing but pollutants kept near ground in atmosphere (when surface of earth is cooler than atmosphere). The most harmful component of smog is ground level ozone and fine airborne particles. Ozone layer near ground increases by photo degradation of NO₂.



Ozone is a strong oxidizing agent and effects respiratory system.

Effect of air pollution on human being

- 1) NO_2 – Highly toxic, causes irritation to eyes.
- 2) NO – combines with hemoglobin and reduces oxygen transport ability of blood.
- 3) SO_2 – Sneezing, coughing, lung cancer.
- 4) CO_2 – Non toxic.
- 5) CO – Highly toxic- Headache, difficulty in breathing.
- 6) Hydrocarbons – Aromatic hydrocarbons are more dangerous and may be carcinogenic.

Effect of air pollution on plants

High concentration of air pollutants damage leaves of plants which reduces photosynthesis and causing spotting of leaf.

Effect on nonliving things

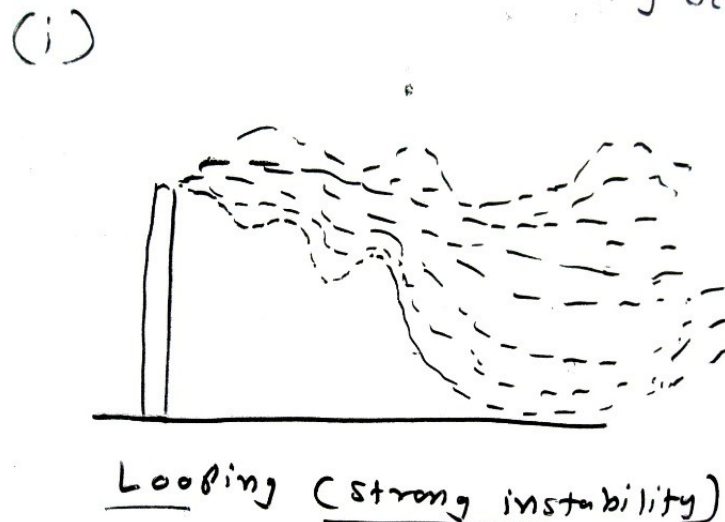
- Metal corrosion.
- Degradation of monuments.
- Degradation of paints.

PLUME BEHAVIOUR

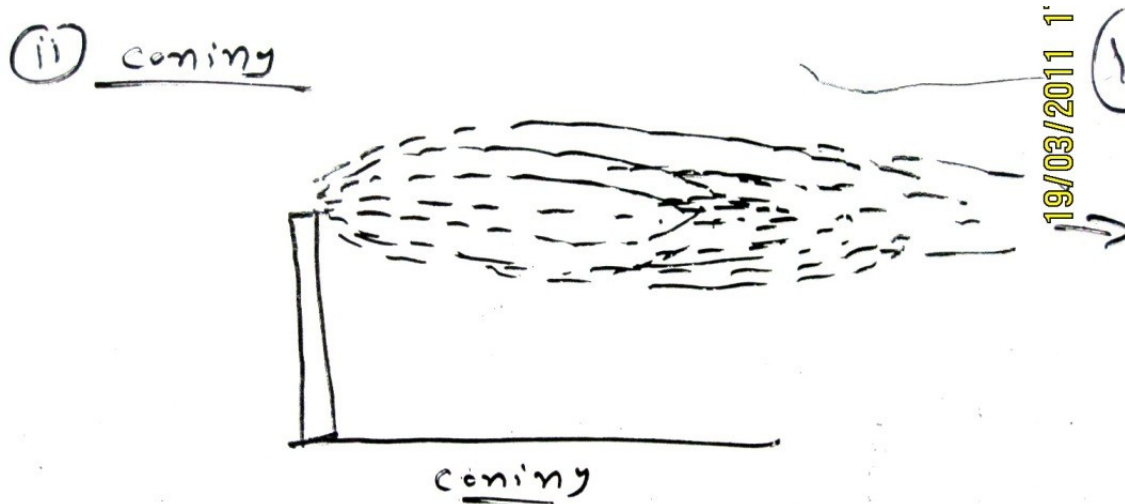
What is plume behavior?

The behavior of plume (gaseous pollutants) emitted from elevated sources such as chimneys depending on degree of instability of atmosphere and prevailing wind turbulence.

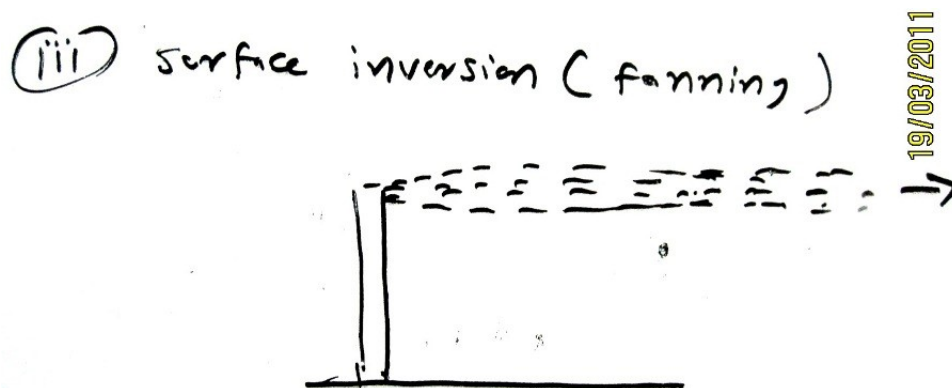
Various situations which may occur are



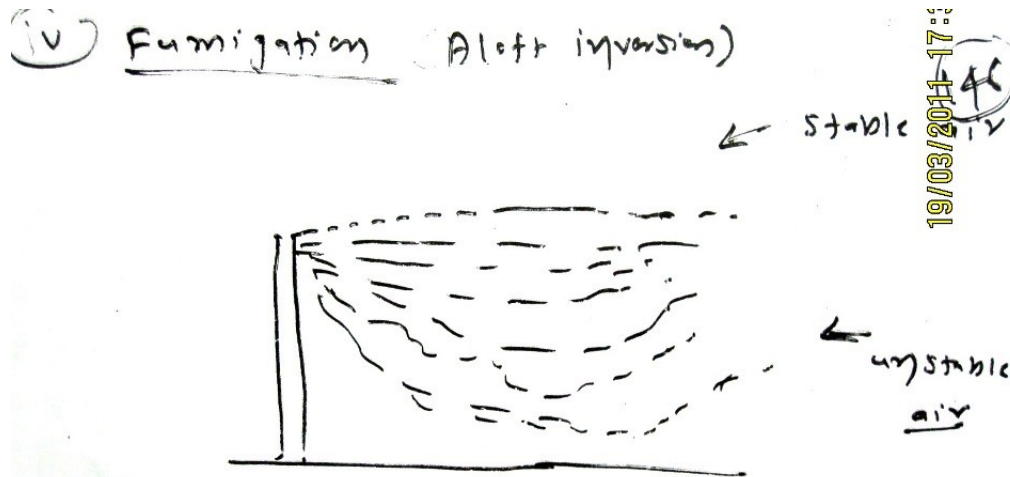
Looping occurs when light to moderate wind speeds in a hot summer afternoon when large scale thermal eddies are present. The portion of the plume is carried out to the ground level for short time, causing momentary high surface concentration of pollutants near the stack (Chimney)



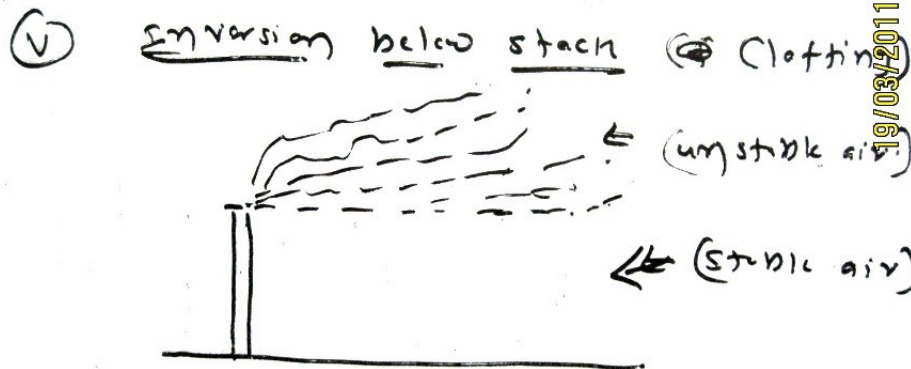
Coning plumes occurs under cloudy skies when lapse rate is neutral (Both day and night). It is associated with moderate to high wind and concentration of pollutants is at much height from the ground.



Fanning occurs when plume is dispersed in presence of very light winds as a result of strong atmospheric inversion (inversion occurs due to difference in temperature of layers of air). The plume travels parallel to ground and does not cause pollution at ground.

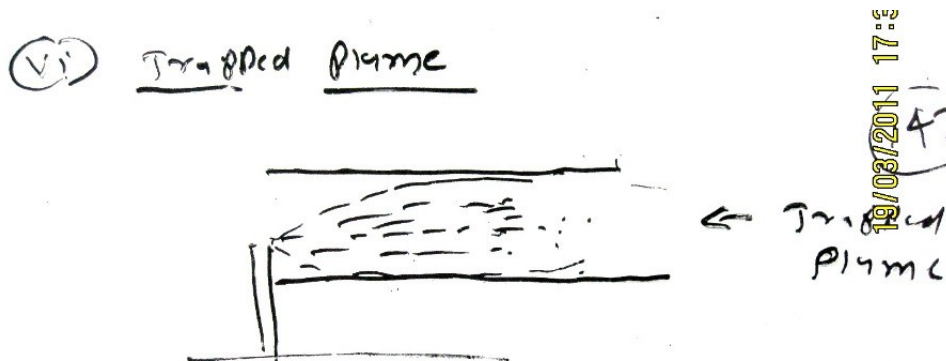


In early morning, after sun rise, a stable layer of air lies a short distance above the release point of plume and unstable air lies below the plume. This unstable layer of air causes the pollutants to move downwards for short time. (This situation is known as fumigation).



Conditions are exactly reverse of fumigation. The upper portion of air is unstable and down is stable.

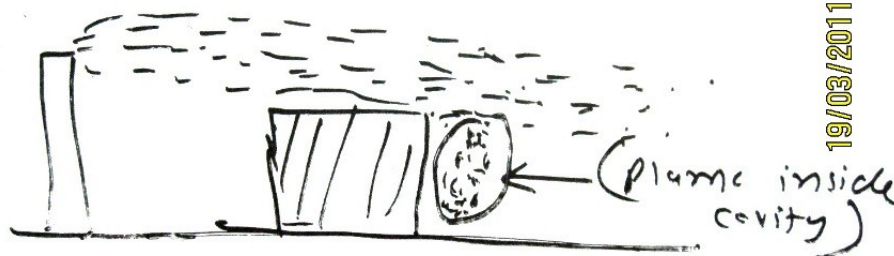
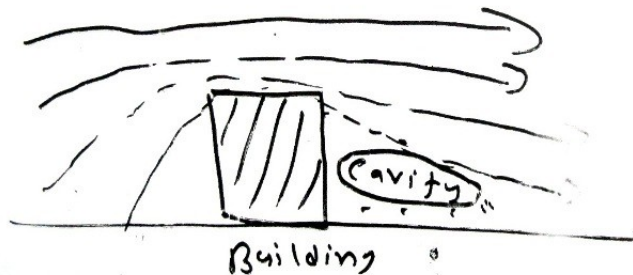
It is most favorable condition as far as ground level pollutants are concerned.



When plume is trapped between two inversion layers. This occurs when inversion lasting for many days.

✓ Plume behavior when chimney is placed near building

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If chimney height is just above the building the plume is trapped in a cavity as shown. Hence chimney should be at least two and half times more than the building.

FATE OF AIR POLLUTANTS

Fate of particulate matter

- 1) Wet precipitation:
 - a) Rainout: Inside clouds the particulate matter serve as condensation nuclei on which water droplets condensate.
 - b) Washout: Particulate matter under the clouds reach the earth along with rain.
- 2) Dry deposition:

Particles of size 0.1 micrometer can coagulate and form large particles which finally settle to earth by gravity.

Fate of gaseous pollutants

- a) Interaction with earth surface:

Due to atmospheric turbulence, gaseous pollutants reach to either surface of sea where they are dissolved or on earth surface where they are absorbed by moist land surface.
- b) Acid Rain:

Pollutant like SO_2 can dissolve in atmospheric moisture to form H_2SO_4 which return to air as acid rain.
- c) Photochemical smog: (Already discussed in previous part)

POLLUTION BOARD (INDIA) EFFLUENT NORMS

pH	6-9
Temperature	40°C
Total suspended solids	100mg/l
Total dissolved solids	2100mg/l
Sulphides	2mg/l
Chlorides	1000mg/l
Sulphates	1000mg/l
Copper	3mg/l
Arsenic	0.2mg/l
Cadmium, Chromium	2mg/l
Lead	0.1mg/l
BOD	30mg/l
COD	250mg/l
Dissolved phosphate	5mg/l

ENVIRONMENTAL POLLUTION LAWS(INDIA)**Environmental pollution act 1986**

It has 4 chapter and 26 sections

- The laws are made for protection and improvement of environment.
- The responsible agency –Ministry of forest and environment.

Chapter I

- It consists of definition of environment, pollutants, pollution, hazardous substance, occupier etc.

Chapter II

- It deals with general powers of central government in relation to protection of environment.
- Government is allowed to take any action which seems to be necessary for protection and improving environment.
- Under this chapter various norms and standards for emission or discharge of pollutants are mentioned.
- Various procedures and safeguards to prevent accident causing environment damage are mentioned in this chapter.
- Guidelines for carrying out research /investigation for environmental problems are listed in this chapter.

Chapter III

This chapter deals with prevention, control, and abatement of environmental pollutions.

Prevention:

- a) Persons carrying out any operation is not allowed to emit/discharge pollutants in excess of standards.
- b) It also checks safeguards in handling of hazardous substance.
- c) Furnishing of information in case of accidental events of discharge where norms are exceeded, the person in charge should:
 - i) Inform government agency immediately.
 - ii) Take necessary action to stop and prevent the further loss.

Control:

- a) Power of entry and inspection for government agencies.
- b) Power to take samples and procedures of manufacturing.
- c) Carry of analysis by government agencies of samples collected and take necessary action.

Abatement:

It deals with.

- a) Penalty for whoever fails to comply with the act.
- b) It also deals with offences by government department on environmental issues.

Chapter IV

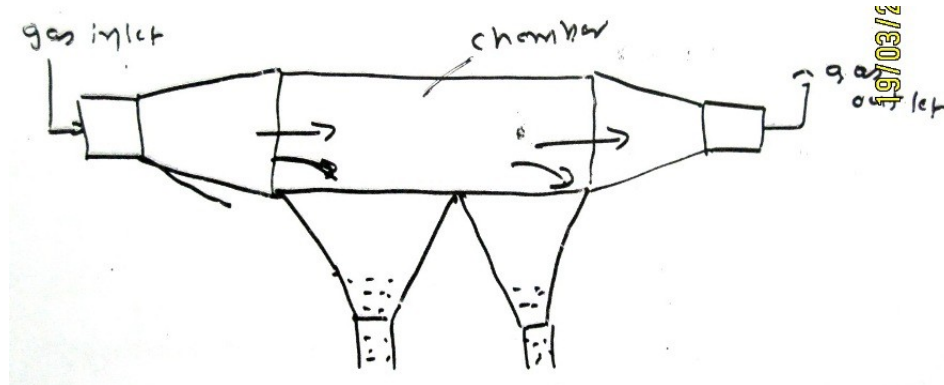
- It deals with powers to make new rules and their approval.
- It deals with handling procedure of hazardous waste.
- It deals with decision of waste disposal sites.
- It deals with rules of importation of hazardous material
- It deals with approval of genetically modified processes.
- It deals with any emergency matter not covered in first 3 chapters.

PREVENTION AND CONTROL OF AIR POLLUTION

- 1) By fuel selection and utilization:
Coal and fossil fuels gives smoke, CO₂, SO₂, as major pollutants. Use of natural gas in place of conventional fuels. E.g. CNG
- 2) Control of air pollution by site selection:
Industries are located away from residential areas and their zones are created e.g. MIDC (Maharashtra Industrial Development Corporation)
- 3) Equipment alternations:
 - Raise the height of chimney.
 - Use of hot air from chimney for heating.
 - Proper maintenance of equipment.
- 4) Removal of pollutant at source:
Some of the volatile pollutants can be recovered before discharge.
- 5) Particulate emission control:
It can be done by internal separators before gases are discharged to atmosphere.

Particulate emission control

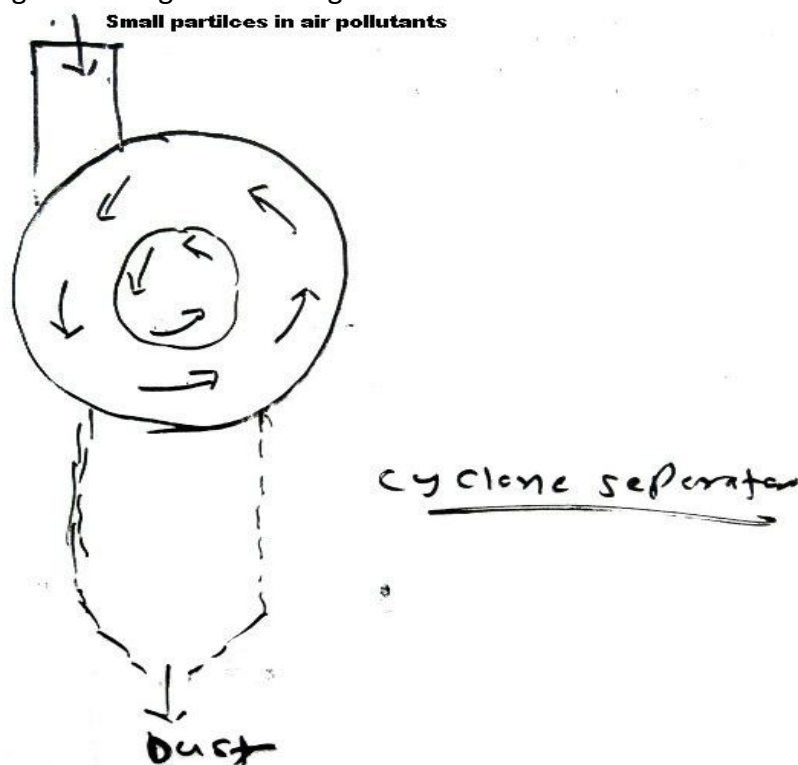
- Particle size in gaseous pollutant may vary between 0.1 micrometer to 100 micrometer.
- A) Gravitational settling:
If particle size in gaseous effluent is more than 50 micrometer, this technique is used.



- Low pressure drop is applied across a chamber which causes particles greater than 50 μm to settle at bottom which are then removed.
- Simple operation.
- Low cost of maintenance.

B) Cyclone separators:

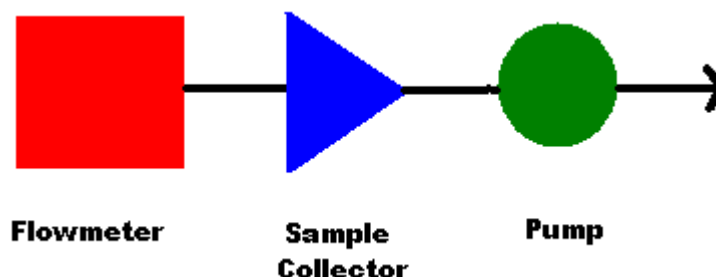
- If particle size is less than 50 μm , gravitational settling cannot be used.
- Cyclone separators use centrifugal force by spinning the gas stream.
- Centrifugal force is greater than gravitational force and hence can be settled.



ANALYSIS OF AIR POLLUTANTS

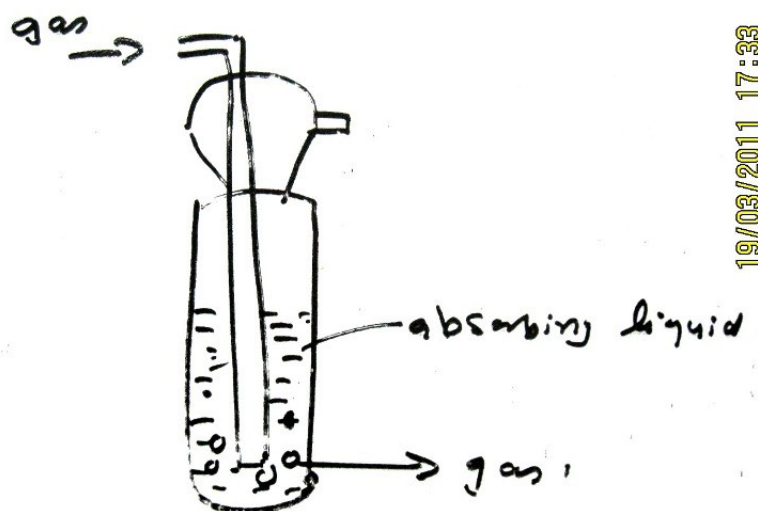
THE FIRST STEP IS COLLECTION OF GASEOUS AIR POLLUTANTS:

- 1) The typical air sampling system consists of flow meter, sample collector and a pump to draw the air.



By use of this instrument measured quantity of pollutant can be collected in sample collector.

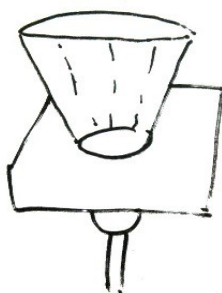
- 2) Grab Sampling:
In grab sampling, sample is collected by filling in evacuated flask. The containers made up of glass or stainless steel are first evacuated and then filled by allowing air to enter.
- 3) Absorption by liquids:
It is one of the most commonly employed methods.



The dissolved gas in solvent is measured by titration.

COLLECTION OF PARTICULATE POLLUTANTS IN AIR

- 1) If particle size in air is more than $10\mu\text{m}$ diameter, it is collected by sedimentation technique. The instrument consists of plastic jar of 25cm height and 15 cm diameter with fine filters.



The air is stored in flask (Closed) for two weeks and weighed to find out the particulate material.

- 2) If particle size is less than $10\mu\text{m}$ than high volume filtration is used. In this method a known volume of air is sucked by high speed blower through a fine filter and increase in weight is measured.

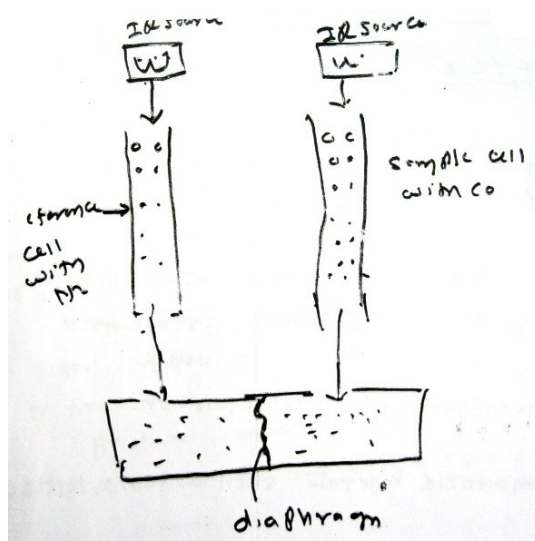
ANALYSIS OF AIR POLLUTANTS

1) Sulphur dioxide:

- In this method sample containing SO_2 is passed through a dilute solution of H_2O_2 in H_2SO_4 .
- SO_2 is oxidized to H_2SO_4 thereby increasing the electrical conductivity of the solution.
- The increase in conductivity is directly proportional to SO_2 in pollutant.

2) Carbon monoxide (CO)

- It is done using Infra red spectrometry. The instrument consists of
- Two cells, one filled with N_2 which cannot absorb IR rays.
- 2nd cell is flushed with CO which can absorb IR Rays.
- Two different IR sources are provided for two cells.



- Infrared can easily pass through N_2 cell while IR can easily absorbed by CO causing its expansion.
- The difference in pressure of two cells is measured using a diaphragm indicating amount of CO in pollutant.

CHAPTER 8: FIRE & ACCIDENTS

TYPES OF FIRES

Class A Ordinary fibre like burning paper, plastic, wood, cotton fluffs etc.

Class B Fire due to flammable and combustible liquids like kerosene, grease and oil.

Class C Energized electrical equipment.

Class D Combustible metals such as Mg, K, and Na.

Types of fire extinguisher used will depend on type of fire.

Sources of fire are short circuits, explosive chemicals

1) Water fire extinguisher:

- Mostly used in textile industry particularly in spinning/weaving departments.
- They are mostly used in type A class of fire.
- Water is never used in class B, C or D class of fire.
- If used on electrical equipment, water being good conductor of electricity, can give shock.
- Metals like Sodium become explosive in presence of moisture.
- Oil tends to float on water and hence it is not effective.
- Water may be used in form of pressurized vessel or hydrant lines are laid inside mill with different colour painted on it.
- Separate hydrant pump is provided to pump the water with pressure through hose pipe.
- There are many points along the hydrant line with facility to attach hose pipe across the mill.
- The hydrant pump could be started with petrol in case of electricity has to be shut due to fire.
- Another important point is enough availability of water for 24x7 in case of fire.

2) CO₂ fire extinguishers:

- CO₂ can be used for B, C, D type of fires. However if fire is in a big way it may not be effective.
- However it is very effective in case of medium types of B, C fires.
- It does not leave any residue and does not require much clean up after fire extinguished.

3) Dry Powder:

- Powder used generally is mono ammonium phosphate, potassium bicarbonate.
- The extinguisher is filled with dry powder and pressurized with N₂ gas.
- It is most effective in case of B, C types of fires.
- It leaves a blanket of nonflammable material on fire and separate it from O₂.
- Dry powder is not used on D type of fibre as it may corrode the metal.
- Lot of cleaning is to be done after fire is extinguished.

- 4) Foam:
 - It can be used in B, C and D type of fires effectively particularly on B type of fires with combustible liquid.
 - It consists of FFFP (Film forming fluoro protein) and forms a blanket on fire which is heat resistant.
- 5) Sand:
 - If fire is extremely small, sand can be used to extinguish it.

PRECAUTIONS AND PRACTICES TO PREVENT FIRE AND ACCIDENTS

- 1) Use right type of fire extinguisher
- 2) Fire extinguisher should be kept at place where it can be easily reached.
- 3) It should be in working order. It should be inspected periodically.
- 4) Training and fire drills: Everybody in a mill should be trained to operate fire extinguisher by authorized bodies. Fire drills should be conducted twice a year.
- 5) Work place assessment of fire hazard should be done and accordingly the type of fire extinguisher kept near the place.
- 6) The water hydrant pump could be operated by petrol/diesel in case electricity is shut down.
- 7) Housekeeping: It is most important factor to prevent and spread of fire. All waste must be disposed off daily.
- 8) Everybody should be aware about fire exits.
- 9) In case of fire there should be
 - a) Fire alarm, b) Head counting for missing persons.
- 10) Any person caught fire, "STOP, DROP, ROLL" mechanism (Stop running)
- 11) Safety manuals: Every worker should have safety manual for safe working practices.

GENERAL SAFETY PRACTICES TO PREVENT ACCIDENTS

- 1) Housekeeping: Proper housekeeping not only reduces fire incidences but also reduces accidents inside a mill.
- 2) Use of safety tools like goggles, gum boots, hand gloves whenever necessary.
- 3) First aid: The mill must be equipped with first aid material in case of smaller accidents.
- 4) Nurse: Company should have round the clock nurse for any emergencies.
- 5) Ambulance: Ambulance should be available to carry patient to hospital in case of emergencies.
- 6) The work place should be well ventilated.
- 7) All exit points should be marked well to vacate the place in case of emergency.
- 8) Safety notices should be displayed everywhere.
- 9) All staff should be well trained about safety tools, practices and its impact on human life.
- 10) Inspection of equipment: All sensitive machines like boiler and high temperature/ high pressure machines should be inspected as per law from government agencies for pressure test etc.

- 11) All firefighting equipment should be placed properly and can be reached easily.
- 12) All staff should have facility for medical checkups in a fixed period of 5 years.
- 13) Proper alarm system/smoke detectors should be installed.
- 14) Personal accident insurance should be done if possible.
- 15) Safety awards: Awards/trophies should be given for no accidents.

Advantages of safety

- 1) Less government interference.
- 2) High moral.
- 3) High productivity/quality.
- 4) No penalties.

MAJOR SAFETY & HEALTH ISSUES IN TEXTILE INDUSTRY

They are

- 1) Exposure to cotton dust.
 - 2) Exposure to chemicals.
 - 3) Exposure to noise.
 - 4) Ergonomic issues.
- 1) Exposure to cotton dust:
 - Particularly in spinning & weaving department.
 - It leads to respiratory disorders e.g. TB etc.
 - The limit of cotton dust in spinning/weaving is 750 micrometer/per cubic meter of air.
- 2) Exposure to chemicals:

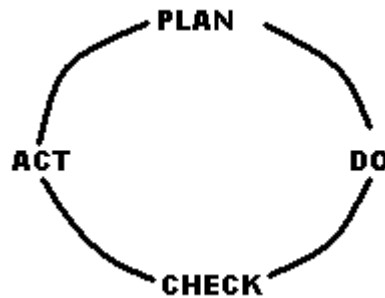
In wet processing chemicals like formaldehyde cause lung cancer.
- 3) Exposure to noise:

Already discussed in previous chapter.
- 4) Ergonomic issues (Manmade problems)
 - Unsuitable sitting arrangement.
 - Improper ventilation.
 - Improper lighting.
 - Lack of safety devices.
 - Unhygienic canteens.

Workers working under such conditions develop lot of occupational diseases like back pain, shoulder pain, neck pain, coughs, colds, improper sleep, fatigue etc.

OCCUPTATIONAL SAFETY & HEALTH

- It is concerned with safety, health and welfare of people engaged in work or employment.
- It can be further extended to family members of employees, customers, suppliers and nearby communities.
- As per world health organization (WHO) it is promotion and maintenance of highest degree of physical, mental and social well being of workers in occupations.
- WHO has suggested the PDCA cycle for this cause.



- 1) Plan: Systematic evaluation of working environment.
- 2) Do: Eliminating reasons for illness of work place.
- 3) Check: Regular medical examination of workers.
- 4) Act: Take necessary action if needed.

ENERGY PLANNING

Definition: It is the manner in which the government decide to address the issue of energy development including energy production, distribution and consumption.

It includes:

- a) International treaties.
- b) Incentives for power projects.
- c) Guidelines for energy conservation.
- d) Taxation, pricing.

Factors considered for energy policy are

- 1) Extent of energy required today.
- 2) Future energy consumption.
- 3) The future energy sources.
- 4) % of population that can accept energy poverty.
- 5) Energy intensity.

Energy Intensity:

Energy intensity is amount of energy consumed in generation of a unit of GDP

In India it is 0.15Kg of oil equivalent per US \$ of GDP.

Meaning of Oil equivalent:

Energy liberated by burning:-1 ton (7.4 barrel) of crude oil = 1270 cubic meter of gas = 1.4 ton of coal.

OR

In terms of BTU (British thermal unit)

In India energy intensity is

32000 BTU/USD GDP (India)

11000 BTU/USD GDP (USA)

Hence,

High energy intensity means high cost of converting energy into GDP.

Low energy intensity means low cost of converting energy into GDP.

ENERGY POLICY OF INDIA

- 1) Enhancement of natural gas consumption.
- 2) Energy conservation and efficient energy utilization i.e. reducing energy intensity below 0.15Kg of oil equivalent.
- 3) Promotion of renewable energy sources like wind energy solar energy, Hydro. In India 60% power generation is by coal. (Thermal power)
- 4) Energy audit.
- 5) Fuel switching to get low carbon emission.
- 6) Improvement of combustion efficiency.
- 7) Power factor improvement.

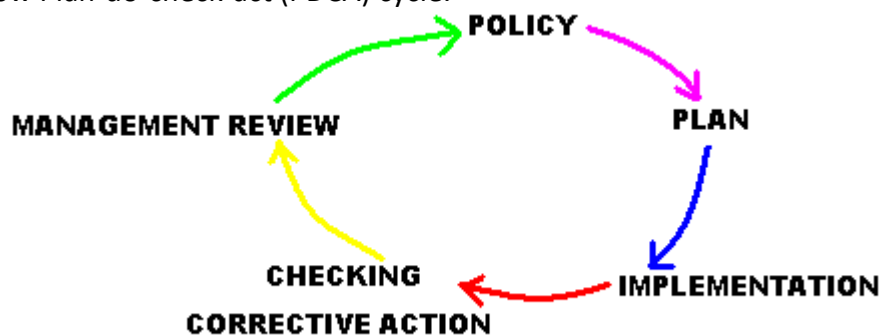
CHAPTER 9: ENVIRONMENTAL MANAGEMENT SYSTEM (EMS)

1) What is EMS?

- It is a management system that deals with developing, implementing, achieving, reviewing and maintaining the organizations, environmental policy.
- It includes:
 - (a) Organizational structure.
 - (b) Planning.
 - (c) Activities.
 - (d) Responsibilities.
 - (e) Practices & procedures.
 - (f) Resources.
- EMS is nothing but systematic way of managing organizations environmental affairs.
- It is tool to improve environmental performance.

2) EMS Model:

EMS follow Plan-do-check-act (PDCA) cycle.



EMS model is continuous as EMS is a process of continuous improvement.

KEY ELEMENTS OF EMS

- 1) Policy statement:
A statement of organization towards commitment to the environment.
- 2) Identification of significant environmental impacts of process.
- 3) Development of objective & targets.
- 4) Implementation.
- 5) Training:
Ensuring the awareness of employees.
- 6) Management reviews.

ISO

ISO is International Organization for Standardization.

It has got 127 members.

Object:

- To promote development of standardization.
- To facilitate international exchange of goods.

ISO 14000

ISO 14000 is a series of International, voluntary, environmental management standards.

Purpose:

- 1) To promote effective & efficient environmental management in organization.
- 2) They work with existing regulatory standards: Provide a way to manage & monitor performance voluntarily.

ISO 14004 Environmental management system (EMS)- General guidelines.

ISO 14010 Guidelines for environmental auditing.

ISO 14011 Audit procedures.

ISO 14012 Qualification criteria for auditors.

ISO 14020/21/22/23/24 – Environmental labels & declaration.

ISO 14042/43 – Dealing with life cycle assessment.

Various Steps involved:

1. Preliminary review & audit:
 - Characterization/quantification of all inputs/outputs.
 - Assessing environmental effects.
 - Identify future performance requirements.
 - Determine current performance.
 - Developing plans to improve performance.
2. Forming Environmental policy:
 - Written statement underlying the top management commitment.
3. Create organizational structure & allocate resources.
 - Nominate management representative.
 - Define his/her role & responsibility.
 - Report to top management regularly.
 - All functional groups like production/engineering, finance, HR should be named with team leaders.
 - Fix their roles & responsibilities.
 - Allocate human resources/finances.
4. Set objectives/targets.
 - In the form of formal communication for top management, so that the entire organization is aware of those.
 - Identify and prioritize specific areas.
 - Improvement target should be practicable.
 - Review program should be established.
5. Standard Operating Procedures (SOP)/ Manual/Traning programme.

6. Implement SOP.

- Any deviation to be documented.
- All documents should have references.
- Any deviation should be highlighted & necessary changes done by approval of top management.