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Industrial Wastewater Treatment

Unit-3

Industrial Wastewater : sources, Types & Env. Impacts, Environmentally balanced Industrial Complexes

① : Pulp & Paper mill complex (75)

② (2020) ← sugarcane complex

③ (2021) ← Textile complex (2020) (2021)

④ Food Processing (C, D, B, Distillery & Cane S) (Saurabh)

⑤ Apparel (Textile, Tannery)

① Pulp and paper mill complex :

↓

Thin material produced by pressing together moist fibres of cellulose pulp which obtained from wood, rags or grasses & drying them into flexible sheets.

The paper mills use the 'pulp' as raw material, which is again produced utilizing different cellulosic materials like wood, bamboo, jute, straw mainly of rice and wheat, waste paper, bagasse etc in the pulp mills.

Manufacturing process :

(Rekha ppt)

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Manufacturing Process :

① **Debarking**

Drum debarking : As drum rotates, the logs tumble and clash against each other, and either in the presence or absence of water elimination of barks takes place by abrasion

② **Chipping**

Debarked logs pass on like a log that moves to the chippers.

③ **Pulping**

Bagasse from the sugar industry can also be used.
The chipped wood or bagasse then proceeds to the pulping process.

Mechanical Pulping	Chemical Pulping	Kraft Pulping	Sulphate Pulping
Defibrillation of timber which takes place mechanically.	largely composed of pure cellulose & removed by chemical treatment process.	Treatment of wood chips with a hot mixture of water, NaOH & sodium sulfide.	Involves the treatment of wood chips with sulfite salt of Ca, Mg, Ammonium, Potassium.

④ **Cooking**

cooking chips cooked for b/w 2 to 6 hrs in digesters to about 10 atm of pressure & temp. of 140°C.

⑤ **Washing and screening**

After washing and screening the pulp is sent to the bleach plant or paper mill.

⑥ **Chemical Recovery system**

① Black liquor from brown-stock washers containing about 16% solid is evaporated.

② Extraction of lignin during chemical pulping can be 50% of pulp prod^{n} of a unified mill.

③ This can be recovered for by-products such as adhesives, resins & epoxy.

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Waste water Generation:

- Amount & characteristics of generated wastewater from pulp and paper industry is depend on type of manufacturing process, raw material, applied technology & recovery process etc.
- Generation:
  - From Raw material preparation : cooling water
  - Pulping : leakage from pipelines
  - Washing & cleaning : Washwater
  - Bleaching : Bleach plant wash water
  - Stock preparation : clean up wastewater
  - Paper machine : white water
  - Finishing : cleanup wastewater

Stages at which waste is produced:

Wood Handling → Cooking → screening → Washing → Bleaching → Drying

- Wood Handling → water flow, sand, bark fibres
- Cooking → Water Flow, Fibres, BOD, COD, P, N

- Produces a waste volume in range of 225 to 320 m^3 per tone of paper manufactured.
- The pulp and paper wastes are characterized by very
  - strong colour
  - High BOD
  - High COD/BOD Ratio
  - High suspended solid

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Treatment of paper and pulp mill effluent :

Influent → Preliminary → Primary (physical) → Secondary (Biological) → Tertiary (chemical) → Effluent

Preliminary
- ① Screening
- ② Grit Removal

Primary (physical)
- ① sedimentation
- ② Filtration
- ③ Flotation
- ④ mem. separation
- ⑤ Precipitation

Secondary (Biological)
- ① Activated sludge
- ② Aerated lagoons
- ③ Anaerobic treatment
- ④ sequential Treatment.

Chemical Precipitation
→ Reduction of coloring matter from wastewater.
→ Aluminium chloride is used.

Membrane Filtration
selective barrier that permit separation of certain species in fluid.

Screening
→ Screen mats to remove course, bulky & fibrous component from influents
→ Grit chambers & settling tank are used.

sedimentation
→ Physical process in which suspended solids are removed using gravity.
→ Depend on size and specific gravity of particles.

Flotation
→ removal of solid on the basis of marginal density diff. b/w solid & water.
→ Basically injecting an aq. stream containing dissolved air into waste water.
→ Dissolved air forms bubbles when it comes out of sol^n — also carries suspended particles which tend to conc. at the top of chamber.

Anaerobic Treatment
CO_2, CH_4 produced
↓
renewable energy source.

Aerobic Treatment
→ Bacteria, fungi, protozoa, microbes
→ O_2 – supplied to effluent

Activated sludge Treatment
→ Treating industrial water using aeration and biological floc composed of microorganism.
→ Take place in aeration tank & settling tank.
→ Air is injected in mixed liquor.
→ biological floc settled.
→ separating biological sludge from clear treated water.

Membrane Bioreactor MBR.
→ Latest technology for biological degradation of soluble organic impurities.
→ Bio-solids are separated by means of polymeric memb. based on microfiltration or ultrafiltration unit.

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Environmental Impact:

- Crude pulp and paper mill wastes or insufficiently treated waste cause very serious pollution problems — when discharged into streams.
- Fine fibres often clog the water intake screen in down stream side.
- Toxic effect may also be induced upon flora and fauna of stream due to phenols and sulphites in water.
- Bottom deposit of lignin:
  Cellulosic materials near the point of discharge of waste in a stream undergo slow decomposition & lead to DO depletion followed anaerobic condn & destruction of aquatic life.

(2) Sugarcane Complex:

↓

Production, Processing & ~~marketing~~ of sugars (sucrose & fructose).
~~sugar~~ extracted from sugarcane & sugarbeet

Manufacturing Process

(1) Sugarcane cut into pieces and crushed in a series of rollers to extract the juice in mill.

(2) Juice is extracted from sugarcane, leaving a fibrous residue called Bagasse,

↓

used as fuel for boilers.

Date.....

(3) The milk of lime is then added to juice and heated – when all colloidal and suspended impurities are coagulated, much of colour removed during lime treatment.

(4) Lime is added to the extracted juice to raise its pH and to prevent the inversion of sucrose molecule into glucose & fructose.

(5) Clarification: Coagulated juice is then clarified to remove the sludge.

(6) The filtrate is recycled to the process & the entire quantity of clarified juice is treated by passing sulphur dioxide gas through it.
↓
sulphitation process (color of juice completely bleached out)

(7) The clarified juice is then preheated and conc. in evaporators & vacuum pans.

(8) Partially crystallized syrup from vacuum pan known as massecuite.
↓
crystallizers
↓
To complete crystallization of sugar.

Massecuite → centrifuged → separate sugar crystal

Remain spent liquor
↓
Black strap molasses
↓
Used in distilleries

sugar dried
↓
Bagged | Packed
↓
Transport.

Date.....

Wastewater Generation & characteristics

Source: → Cleaning operations
→ Washing of milling house floor
→ From various division of boiler house like evaporators, clarifiers, vacuum pans, centrifugation.
→ Leakages from pumps, pipelines
→ Boiler blow down, spray pond overflow, condenser cooling water.
→ Filter cloths used for filtering juice need occasional cleaning.

Characteristics:
Brown colour
Low pH, High Temperature, High BOD, High COD, odour problem, Total solids, High % of dissolved organic & inorganic matter.

It contains — carbohydrates, nutrients, oil & grease, chlorides, sulfates & heavy metals.

Environmental Impacts

- The fresh effluent from sugar mill decomposes rapidly after few hrs of stagnation.
- Considerable difficulties when their effluent gets an access to watercourse.
- Rapid depletion of oxygen due to Biological oxidation followed by anaerobic stabilization of waste cause 2° pollution of offensive odour & black colour.

Date.....

Treatment Methods:

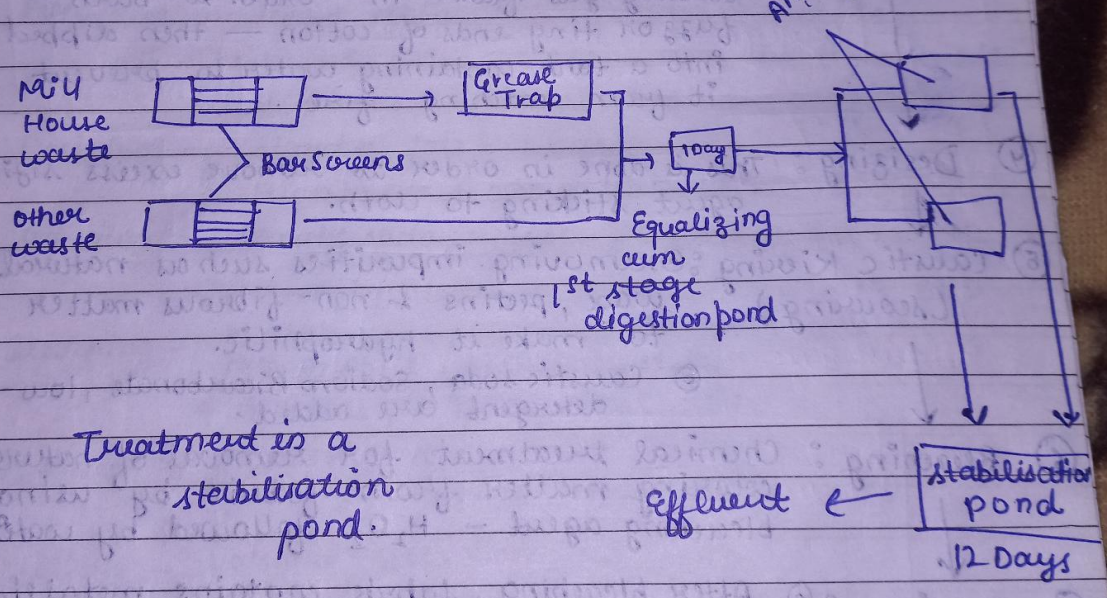
Biological Methods:

Aerobic Treatment: Degradation of organic in the of oxygen.
It includes – Activated sludge,
Trickling filters,
Aerated lagoons

Anaerobic Treatment:
~~Anaerobic Batch reactor~~
AFR: Anaerobic fixed bed reactor
UAFB: Up-flow anaerobic fixed Bed reactor
UASB: Up-flow anaerobic sludge blanked "

Physico-Chemical Methods:

Coagulation / Flocculation
Electrochemical Treatment includes:
Electro-Oxidation
Electro-Coagulation
Electro-floatation



Treatment is a stabilisation pond.

Four grps: Cotton | Wool | Regenerated | Synthetics

Date.....

(8) **Textile Complex:**

Production, development, processing, manufacture and distribution of textile and fabric materials occur.

Manufacturing process

(1) Spinning: Process of winding together drawn out-strands of fibres to form a yarn or making out thread of raw fibres.

(2) Weaving: process of taking threads & making them into cloth.

(3) Sizing: ⊙ process of giving a protective coating on the warp yarn to minimize yarn breakage.
⊙ sizing agents: starch, carboxymethyl cellulose
⊙ The woven passed quickly btw 2 rows of burning gas flame in order to burn fuzz or tiny ends of cotton — then dipped into a tank containing water to prevent it from catching fire.

(4) Desizing: This is done in order to remove excess sizing agent sticking to cloth.

(5) Caustic Kiering (scouring): ⊙ removing impurities such as natural wax, pectins & non-fibrous matter to make it hydrophilic.
⊙ Caustic soda, Sodium Bicarbonate, low-BOD detergent are added.

(6) Bleaching: Chemical treatment for removal of natural coloring matter from fabric by using bleaching agent – H_2O_2 followed by water wash.

(7) Souring: ⊙ After bleaching, fabric contains metallic salts such as $CaCO_3$, Magnesium carbonate etc.
⊙ Bleached cloth is treated with a dilute acids (sulfuric acid) and washed thoroughly — complete removal of alkaline chemicals.

Date.....

(8) Mercerizing: Process in which textiles are treated with a caustic (NaOH) soln to improve properties such as fiber strength, shrink-age resistance, luster & dye affinity.

(9) Sowing: Mercerized cloth is washed first with dil. acid to remove traces of caustic soda.

(10) Dyeing and Printing:
- Dyeing — interaction b/w a dye & a fibre as well as movement of dye into the internal part of fibre.
- Printing: - Process of decorating textile fabrics by application of pigments, dyes.

Wastewater Generation & characteristics:

Pollutant in Textile effluents: suspended solids, mineral oil, grease, non-biodegradable surfactants, Residual chlorine, sulphur.

Desizing – Starches, fats & waxes
- High BOD (about 45% of total)

Scouring – Caustic soda, waxes, greases, soda ash & fibrous matter.
- strongly alkaline, dark brown high BOD.

Bleaching – caustic soda, acids, sodium silicate, Hypochlorite, chlorine, H_2O_2.
- Alkaline, 4% of total BOD.

Mercerizing – Caustic soda
- strongly alkaline, low BOD

Dyeing – various dyes, chemical, soap
- strongly colored with varying hues, about 4% of total BOD.

Printing – colors, thickeners, auxilaries
- Highly colored, about 8% of total BOD.

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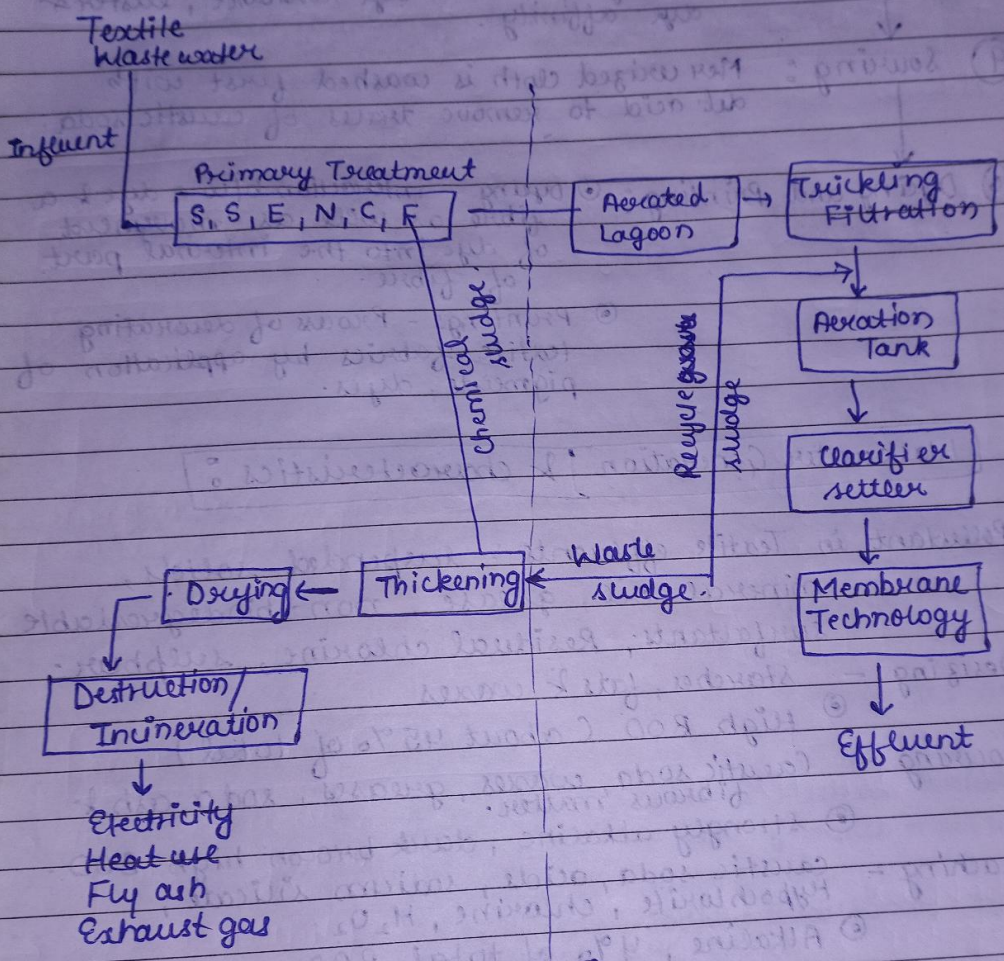
Treatment methods:



Primary Treatment → screening
sedimentation
Equalization
Neutralisation
Chemical coagulation
Mechanical Flocculation.

Date.....

Screening : Rags, pieces of fabric, fibres, yarns removed. Bar screens & mechanically cleaned screens remove most of fibres.

Sedimentation : useful for high % of settlable solids. Settled sludge removed from sedimentation tanks by mechanical scrapping into hoppers.

Equalization : Mixed effluents are stirred by rotating agitators.

Neutralisation : Normally, pH values of cotton finishing effluents are on alkaline side. pH value should be adjusted by use of diluted sulphuric acid.

Chemical & Mechanical Flocculation : Finely divided suspended solid & colloidal particles can't removed by sedimentation. In mechanical flocculation, textile wastewater passed through a tank under gentle stirring — the finely divided suspended solid coalesce into larger particles & settle out.

Secondary Treatment :

Aerated Lagoon : Holding / Treatment pond provided with artificial aeration to promote biological oxidation of wastewater.

Trickling Filter : Easiest step of reducing the BOD5 b/w 50& 70%. Microorganisms are attached and through which wastewater is percolated or trickled downward & causes a layer of microbial slime to grow.

Activated sludge : Treating sewage & industrial wastewater using air & biological floc composed of bacteria & protozoa. Uses air and microorganisms to biologically oxidize organic pollutants.

Oxidation Ditch : large, shallow ponds that are designed to treat wastewater through the interaction of sunlight, bacteria and algae.

Date.....

Chemical Treatment | Tertiary Treatment:

Ozonation: Very effective and fast decolourising treatment.
Can easily break the double bonds present in most of the dyes.

Adsorption: Used to remove colours and other soluble organic pollutant from effluent.
Adsorbent: Activated carbon.

Ion Exchange: Used for removal of inorganic salts.
Salt composed of +ve ion & -ve ion.

Membrane Technology: Uses the membrane micro pores to filter & makes use of membrane selective permeability to separate certain substances in WW.

- ↓ Ultra filtration [more & suspended solid]
- ↓ Nano-filtration [Ca, Mg, Bacteria, virus, colour]
- ↓ RO [Total dissolved solid along with ion & larger specie]

Environmental Impacts:

→ The crude waste, if discharged into streams causes rapid depletion of DO of streams.

→ The alkalinity & toxic substances like sulphides and chromium affect aquatic life and interfere with biological treatment process.

→ some dyes found more toxic.

IWT

Date.....

(4) Food processing : Cannery Waste
a factory where food is canned.

Method of preservation of food in which food is processed & sealed in containers.

Process involves :

Selection — fruit, vege. fresh, free from insect damage.

↓

Sorting and Grading — Done by hand/ grading machine

↓

Washing — soaking in water — cold & hot water spray

↓

Peeling — Metal blade, Hand peeling, mechanical peeler

↓

Blanching — Treatment of Fruit & vege. with boiling water for short period followed by cooling. Loosing the skin, Inactivate the enzyme.

↓

Can filling — Before filling amt. of syrup (Fruit) & brine (for vege.) is poured.

↓

Syruping & brining — 35-40% sugar syrup, 1-2% brine at 79-82°C — fill interspace b/w F & V..

↓

Clinching & lidding — covered with lid.

↓

Exhausting — Passed through water at 82-87°C — Time varies from 5 to 25 min. Reduce risk of corrosion

↓

Sealing — Sealed by special closing machines known as double seamers.

Material in WW of Canning Industries :

Protein, starch, some simple sugars, Volatile fatty acids, Detergent, Water & disinfectants.

Date.....

Wastewater Treatment

- **Primary (Physical)**
  - screening
  - sedimentation
  - Equalization
  - Neutralisation
  - Chemical Coagul.
  - Mech. Flocculation
- **Secondary (Bio)**
  - Activated Sludge
  - Oxidation Ditch
  - Aerated Lagoon
  - Trickling - Filtration
- **Tertiary (chemical)**
  - Membrane Filtration
    - NF
    - UF
    - RO
    - MF
  - Ion Exchange Ads.
  - ~~Adv. Oxidⁿ Process.~~

Dairy Waste :

sources of wastewater

① Processing waters : water used in cooling & heating processes — require minimum treatment.

② Cleaning wastewaters : cleaning of ~~wastewater~~ equipment that has been in contact with milk or milk products. Require Proper treatment

③ sanitary wastewater : piped directly to a sewage works.

Characteristics

Dissolved sugar proteins & fats
BOD (0.8 to 2.5 kg/metric ton).
COD (1.5 time BOD level)
Total suspended solid
Total dissolved solid
Phosphorus, Nitrogen
Cream, butter, cheese ⟶ BOD sources.
Wastewater contain pathogens
Deplete DO — Anaerobic condⁿ — odour — nuisance cond
Toxic for aquatic life — Breeding place for flies
Eutrophication

Date.....

Treatment Methods

Primary (Physical)
↓
sedimentation
Flotation

Secondary (Biological)
① Anaerobic Treatment (Anaerobic pond, digester)
② Aerobic (Activated sludge ~~Trickling Filtration~~)

Tertiary (Chemical)
Membrane method
Ion-Exchange
RO
Disinfection

Brewery Industry — Beer production

Brewery is a water intensive process.
Soft drink obtained through alcoholic fermentation, using selected ~~yeasts~~ yeasts of genera Saccharomyces, of wort prepared from malt cereals, mainly barley, and other amylases — to which were added hop flowers, or their derivatives & adequate water.

Production :

Malt → Mashing → Filtration → Wort Boiling → Fermentation → Clarification → Boiling

Wort Production

Date.....

Wastewater :=>

→ Contains high BOD as a result of all the organic components such as sugar, soluble starch, ethanol & volatile fatty acid used in brewing process.

→ Has High temp. = 25 to 38°C.
High pH = 2 & 12
amount & type of chemical used in cleaning & sanitation process.

→ Organic components — easily biodegradable & consist of sugar, soluble starch, ethanol, fatty acids leading to BOD/COD a ratio of 0.6 to 0.7.

→ Nitrogen and phosphorus — depend on handling of raw material and amt. of spent yeast present in effluent.

→ High suspended solids.

Treatment

Preliminary	Primary (Physical)	Secondary (Biological)	Tertiary (Chemical)
↓	↓	↓	↓
Screening. Grit Removal	Sedimentation	Anaerobic Treatment.	Coagulation Flocculation Neutralisation Flotation

(Distillery and cane - sugar) Date.....

Distillery Waste:

↓

strong alcoholic drink made by distilling
→ by fermentation & distillation process.

→ 3 to 10 kg of molasses produce 1 lt. of alcohol

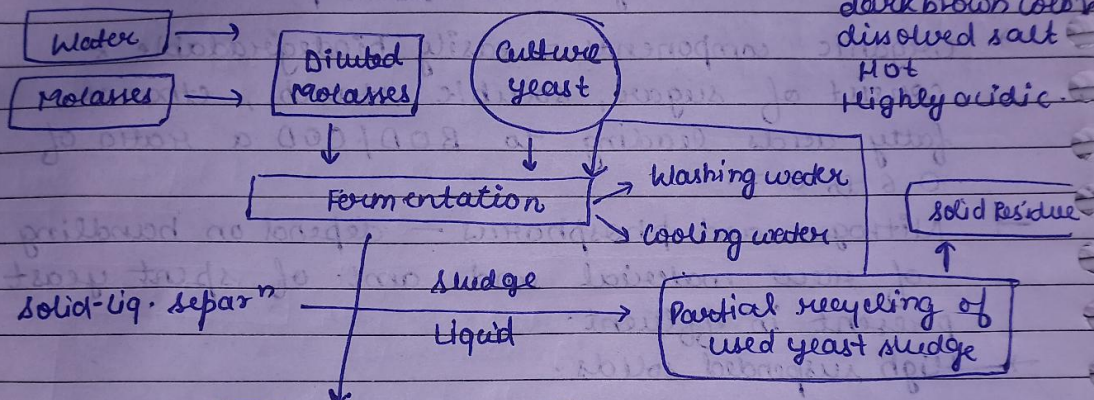
↓

10 to 15 Lt - Spent wash.

↓

dark brown color
dissolved salt
Hot
Highly acidic.

Process



Date.....

Waste streams

- spent wash
- spent lees → liq. left in container with sediment
- Yeast sludge → 30% solid settles down in fermentation vats – major source of waste

Wastewater sources

Stillage
Fermenter
Condenser
Cooling water
Fermenter washwater

Characteristics:
pH low
High BOD, COD
Total dissolved solid
suspended solid
Chlorides.
P, N, Volatile solids

Treatment

Physical Methods
Sedimentation,
Aeration,
Screening,
Membrane Technologies
Flotation

Biological Methods
① Anaerobic Processes
- Anaerobic digestion (remove 90% BOD) → CH_4 by product
- Anaerobic lagooning → remove 95% BOD

② Aerobic Processes
Trickling filters
Activated sludge.

Chemical Methods
Chlorination
Coagulation
Adsorption
Ion exchange

Date

(a place where leather is made by treating animal skin with chemicals)

⑤ Apparel (Tannery Waste)

Manufacturing process

① Preparation of Hides ② Tanning Proper ③ Finishing

Curing - drying it with salt or air

Washing - Remove dirt, salt, blood, manure, non-fib. protein

Soaking - Restore the moisture lost during preservation & storage by soaking in water in NaCl & Antimocin for 1 to 5 days.

UnHairing - Hides are limed with paste of lime cleaning of hairs & fleshings.

Deliming & Bating - Prepare hides for tanning by reducing the pH, reducing swelling & protein degradation products.

Bating - leather slippery, smooth.

Pickling : For chrome tanning.
Treatment with NaCl & acid to prevent ppt of chromium salt.

Degreasing Remove natural grease - allows penetration of tanning liquors.

IInd stage : Tanning Proper

① Vegetable Tanning for heavy leathers, chrome tanning is used for light leathers.

② In chrome tanning - adding a soln of chromium sulphate.

③ After 4 hrs - leather bleached - with sodium thiosulphate & Na_2CO_3 in same bath.

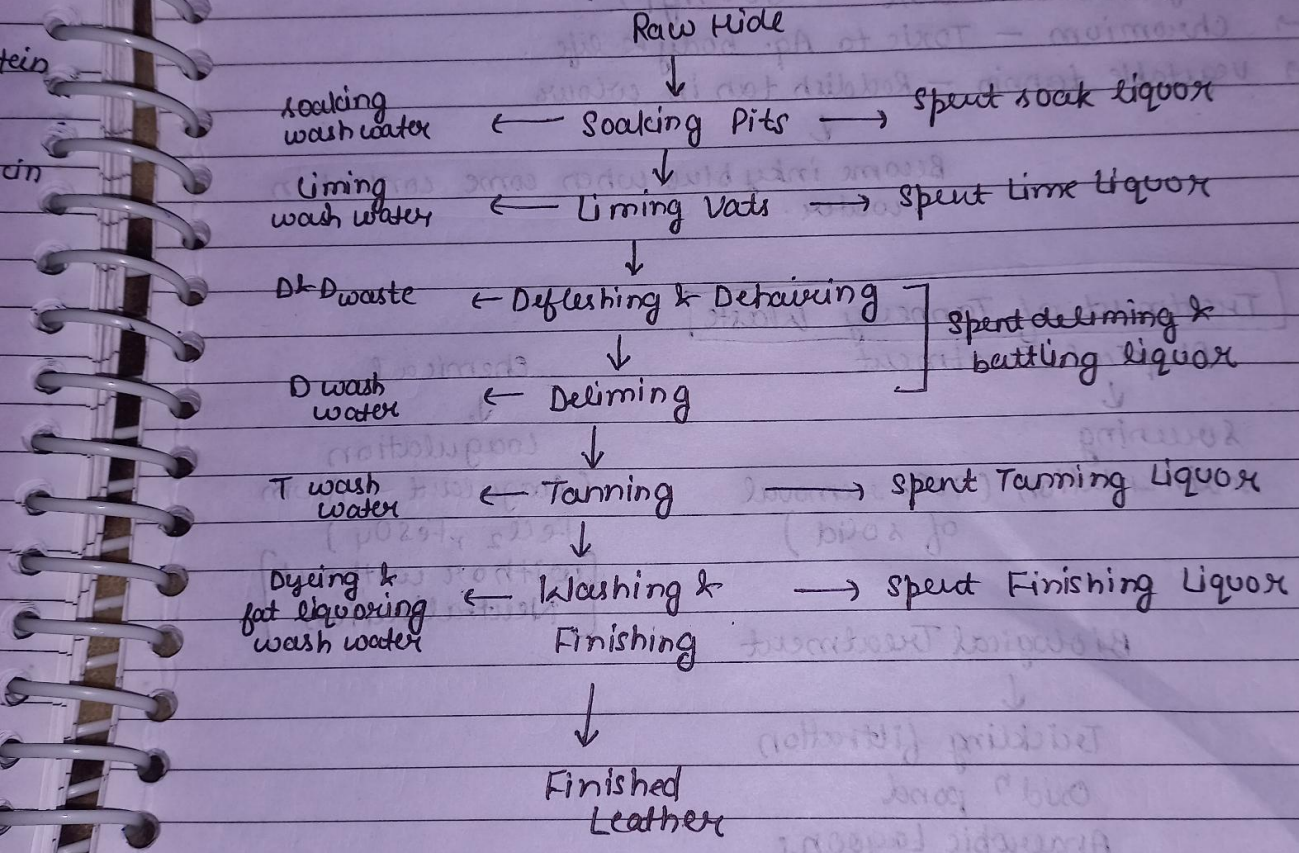
④ Tanned leather is taken out.

Date.....

3rd stage: Finishing

→ Stuffing & fat liquoring: oil & grease - Become soft & resistant to tearing.

→ Dyeing → Done with synthetic dyestuffs.



Intermittent flow of wastewater

Sources: Originate from all operation.

: spent liquors from processes

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small in vol. but highly polluted.

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Effect of waste on receiving stream:

→ High BOD
→ High SS, strong colour
→ Depletion of DO ∴ chemical & biological oxidⁿ of sulphur & oog. comp.
→ High chloride conc. > 500 mg/L.
→ Chromium – Toxic to Aq. body & life.
→ Vegetable tannin – Reddish tan in colour
↓
Become inky blue when come contact in water.

Treatment of Tannery Waste

Physical Treatment
↓
Screening
Sedimentation (90% removal of solid)

Chemical
↓
Coagulation
(Coagulant – Alum $FeCl_2$, $FeSO_4$)
[with or without Neutralisation]

Biological Treatment
↓
Trickling filtration
Oxidⁿ pond
Anaerobic Lagoons