CBCS SCHEME

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17CV71

# Seventh Semester B.E. Degree Examination, Feb./Mar. 2022
## Municipal and Industrial Wastewater Engineering

Time: 3 hrs. Max. Marks: 100

**Note:** ***Answer any FIVE full questions, choosing ONE full question from each module.***



### Module-1

1 a. Explain the different types of sewerage system with their advantages and disadvantages. **(10 Marks)**

b. With neat sketch, explain the septic tank. **(04 Marks)**

c. Explain the basic principles of house drainage system. **(06 Marks)**

**OR**

2 a. The drainage area of one sector of a town is 12 hectares. The classification of the surface of this area is as follows :

| % of total surface area | Type of surface | Coefficient of runoff |
|---|---|---|
| 35 | Hard pavement | 0.85 |
| 10 | Roof surface | 0.80 |
| 20 | Unpaved street | 0.20 |
| 25 | Garden and lawn | 0.20 |
| 10 | Wooden area | 0.15 |

If the time of concentration for the area is 30 min, calculate the maximum runoff using Rational method. use $i = \frac{900}{t+60}$. **(08 Marks)**

b. With neat sketch, explain the component parts of a manhole. **(06 Marks)**

c. With neat diagram, explain the non – circular sewers. **(06 Marks)**

### Module-2

3 a. Explain the Oxygen Sag Curve. **(06 Marks)**

b. Discuss the zones of purification. **(08 Marks)**

c. A waste water effluent of 560 ℓ/sec with a BOD = 50 mg/ℓ , DO = 3.0 mg/ℓ and temperature of 23 °C enters a river where the flow is 28$m^3$/sec and BOD = 4.0 mg/ ℓ , DO = 8.2 mg/ℓ and temperature of 17 °C. $K_D$ of the wastewater = 0.10 per day at 20 °C. The velocity of water in the river downstream is 0.18 m/sec and depth of 0.12m. Determine the following after mixing of wastewater with the river water.

i) Combined discharge ii) BOD of mixture iii) DO of mixture

iv) Temperature of mixture. **(06 Marks)**

**OR**

4 a. A town has a population of 1,00,000 persons with a 200 ℓpcd. Design a sewer when it is running full at maximum discharge. Take a constant value N = 0.013. The sewer is to be laid at a slope of 1 in 500. Take peak factor = 3. Use Manning's formula. **(10 Marks)**

b. Explain the Self cleansing velocity and non scouring velocity. **(06 Marks)**

c. Outline the preventive measures for sewage sickness. **(04 Marks)**

## Module-3

5 a. Explain Aerobic process and Anaerobic process of decomposition of Organic matter. **(06 Marks)**

b. With neat flow diagram, explain the treatment of Municipal Wastewater. **(10 Marks)**

c. Briefly explain Screening and its types. **(04 Marks)**

**OR**

6 a. Design a high rate trickling filter for the following data :
i) Flow : 4.5 Mℓd ii) Recirculation ratio : 1:4
iii) BOD of raw sewage : 250 mg/ℓ iv) BOD removed in primary clarifier : 25%
v) Final effluent BOD desired : 50mg/ℓ.
Also determine the size of the standard rate trickling filter to accomplish the above requirements. **(10 Marks)**

b. Briefly explain :
i) Activated Sludge Process (ASP) ii) Sequential Batch Reactors (SBR). **(10 Marks)**

## Module-4

7 a. Outline the differences between Domestic and Industrial waste water. **(08 Marks)**

b. Explain the effects of effluent discharge on the stream water quality. **(04 Marks)**

c. Define Volume Reduction. Explain the various methods of volume reduction being adopted in the industries. **(08 Marks)**

**OR**

8 a. Explain the process involved in removal of Organic solids. **(10 Marks)**

b. List and explain the methods of removal of colloidal solids from waste water. **(10 Marks)**

## Module-5

9 a. With the help of a flow chart, explain the treatment units suggested to treat waste water from a cotton and textile industry along with waste water characteristics. **(10 Marks)**

b. Outline the sources and characteristics of the wastewater from diary industry. **(10 Marks)**

**OR**

10 a. Explain with flow diagram, treatment option for sugar mills. **(10 Marks)**

b. With the help of flow chart, mention sources and characteristics of waste water from Pharmaceutical Industry. **(10 Marks)**

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# 17CV71-MIWWE VTU 2022 SOLUTION

**1**.

Classification of Sewerage System
1. Combined system
2. Separate System
3. Partially separate system

Combined System

When only one set of sewer is laid carrying both the sanitary sewage and the storm water is called as combined system. Sewage and storm water both are carried to the treatment plant through combined sewers.

Merits
1. Size of the sewers being large, chocking problems are less and easy to clean.
2. House plumbing can be done easily and it proves economical as one set of sewers are laid.
3. Because of dilution of sanitary sewage with storm water nuisance potential is reduced and can be easily and economically treated.

Demerits
1. Size of the sewers being large, difficulty in handling and transportation.
2. Load on treatment plant is unnecessarily increased.
3. It is uneconomical if pumping is needed because of large amount of combined flow.
4. Unnecessarily storm water is polluted.

Suitable conditions for combined system
1. Rainfall in even throughout the year.
2. Both the sanitary sewage and the storm water have to be pumped.
3. The area to be sewered is heavily built up and space for laying two sets of pipes is not available.
4. Where Effective or quicker flows have to be provided.

Separate System

In this system, two sets of sewers are laid .The sanitary sewage is carried through one set of sewers called sanitary sewers, while the storm water is carried through another set of conduits called drains. The sewage is carried to the treatment plant and storm water is directly discharged into the river or streams for disposal

Merits
1. Size of the sewers is small.
2. Sewage load on treatment unit is less.
3. Rivers or streams are not polluted.
4. Storm water can be discharged into rivers without any treatment.

Demerits
1. Sewers being small, cleaning is difficult.

2. Frequent choking problem will be there.
3. System proves costly as it involves two sets of sewers.
4. The use of storm sewer is only partial because during non-monsoon seasons, they will be idle and forms the dumping places for garbage and rubbish and may get clogged.

Suitable conditions for separate sewerage systems

1. Where rainfall is uneven.
2. Where sanitary sewage is to be pumped.
3. The drainage area is steep, allowing to runoff quickly.
4. Sewers are to be constructed in rocky strata. The large combined sewers would be more expensive.

Partially Combined or Partially Separate System

Sometimes a part of storm waters especially that originating from the roofs or paved courtyards of buildings, is allowed to be admitted into the sewers and similarly, the domestic sewage is allowed to be admitted into the drainage. The resulting system is called as partially separate or partially combined system.

Merit

1. The sizes of sewers are not very large as some portion of storm water is carried through open drains.
2. Combines the advantages of both the previous systems.
3. Silting problem is completely eliminated.

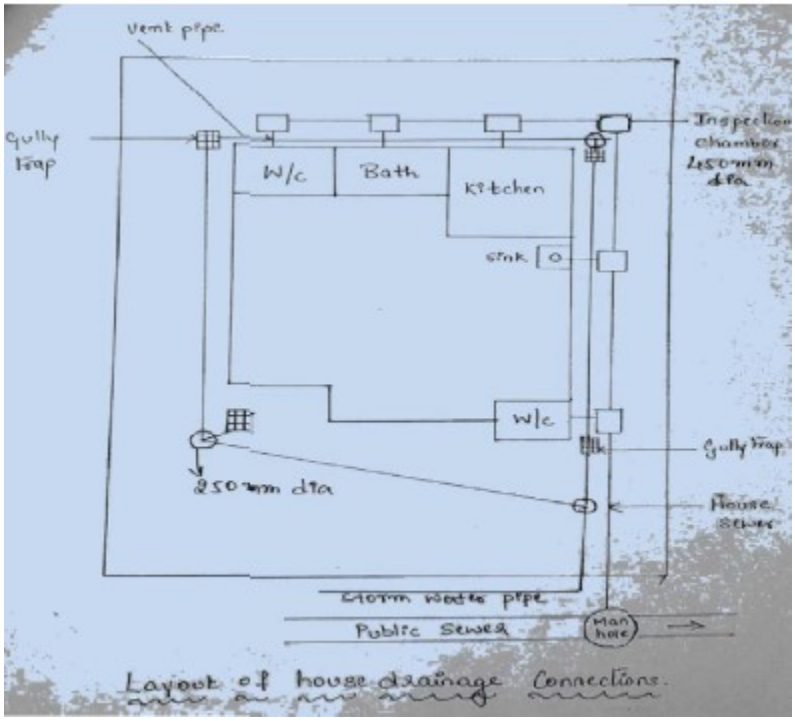
Demerit

1. The cost of pumping is increased at the disposal point than separate system because a portion of storm water is mixed with sanitary sewage.
2. During dry weather, the velocity of flow may be low.
3. The storm water is unnecessary put load on to the treatment plants.
4. Pumping of storm water in unnecessary over-load on the pumps.

Basic principles of house drainage

1. Lay the sewers by the side of the building rather than below the building.
2. Drains should be laid straight between inspection chambers, avoiding sharp bends and junctions as far as possible
3. House drain should be connected to the public sewer only when public sewer is deeper than the house drain in order to avoid reverse flow.
4. Joints of sewer should be water tight and should be properly tested before putting the drainage line to use.
5. Lateral sewers should be laid at proper gradient so that they cleansing velocity.
can develop self
6. Size of the drain should be sufficient so that they do not over flow at the time of maximum discharge.
7. Layout of the house drainage system should permit easy cleaning and removal of

obstructions.
8. Entire system should be properly ventilated from the starting point to the final point of discharge
9. All the materials and fittings of the drainage system should be hard, strong and resistant to corrosion. They should be non-absorbent type.
10. The entire system should be so designed that the possibilities of formation of air locks,
11. Rain water pipes should drain water directly into the street gutters from where it is carried to the storm water drain




SEPTIC TANK

♦ A septic tank may be defined as primary sedimentation tank with a longer detention period (12 to 36hrs, against a period of 2hrs in an ordinary sedimentation tank), and with extra provision for digestion of the settled sludge.

♦ The digestion of the settled sludge is carried out by anaerobic decomposition process; the septic tank unit is generally classified under the units which work on the principle of anaerobic decomposition.

♦ The septic tank is a horizontal continuous flow type of a sedimentation tank, directly admitting raw sewage, and removing about 60% to 70% of the dissolved matter from it.

♦ The sludge settled at the bottom of the tank, and all the oils and greasy matter rising to the top surface of the sewage as scum, are allowed to remain in the tank for a period of several months, during which they are decomposed by the anaerobic bacteria to form gases and liquids by the process of sludge digestion.

♦ Septic tanks are generally provided in areas where sewers have nit been laid and for catering to the sanitary disposal of sewage produced from isolated communities, schools, hospitals, hotels, other public institutions, etc.

♦ Suspended solids removal is 50 to 70 percent; five-day BOD removal is about 60 percent.

Fig. 5.9 Septic tank without soak pit

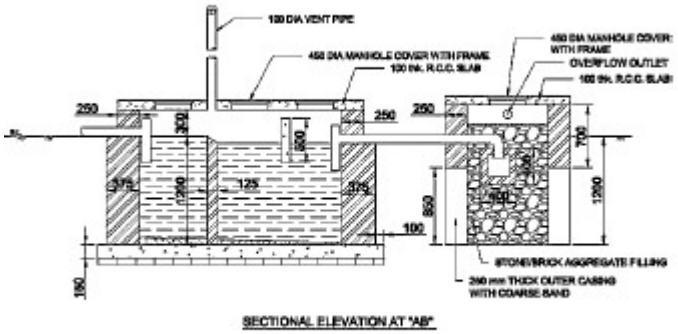



Fig. 5.10 Septic tank with soak pit



Working Principle: A septic tank is a watertight tank designed to slow down the movement of raw sewage and wastes passing through so that solids can separate or settle out and be broken down by liquefaction and anaerobic bacteria action. It does not purify the sewage, eliminate odors, or destroy all solid matter. The septic tank simply conditions the sewage so that it can be disposed of normally to a subsurface absorption system without prematurely clogging the system.

Design Consideration:

(1) Capacity of the Septic tank:

♦ The volume of liquid which a septic tank can accommodate is called its capacity.

♦ Capable of storing the sewage flow during the detention period. An additional volume sludge for 6 months to 3 years.

♦ Only water closets connected – 40 to 70 liters/capita/day.

♦ When Sullage is also discharged – 90 to 150 liters/capita/day.

♦ The rate of sludge accumulation – 30 liters/person/year.

♦ Minimum capacity of septic tank for about 8 to 10 persons may be 2,250 and 1,400 Liters.

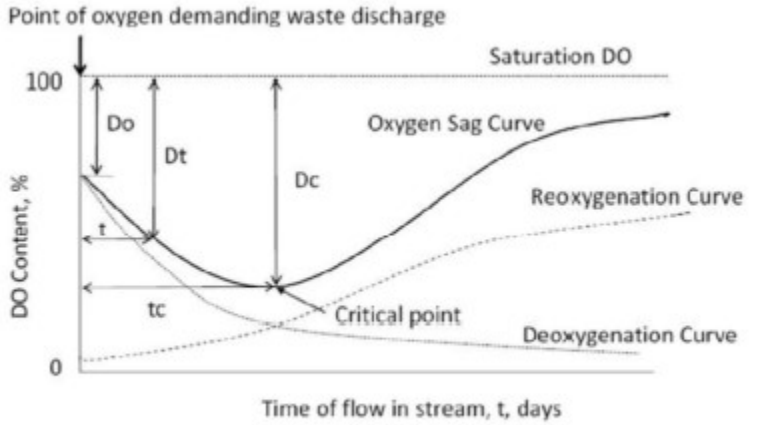
(2) Inlet and Outlet baffles:

Baffles extended up to top level of the scum (about 20-22cm above the top sewage line), but must stop a little below the bottom of the covering slab (by atleast 7.5cm or so). Inlet should to penetrate by about 30cm below the top sewage line, and the outlet should penetrate to about 40% of the depth of the sewage. The outlet invert level should be kept 5 to 7.5cm below the inlet invert level.

(3) Detention Period:
The detention period for a septic tank generally varies between 12 to 36hrs, but commonly adopted as 24hrs.
(4) Length to Width Ratio:
Septic tanks are usually rectangular with their length at about 2 to 3 times the width. The width should not be less than 90cm. The depth of the tank generally ranges between 1.2 to 1.8m.

**2.**

Oxygen Sag Curve:
The oxygen sag or oxygen deficit in the stream at any point of time during self purification process is the difference between the saturation DO content and actual DO content at that time. The amount of resultant oxygen deflect can be obtained by algebraically adding the de oxygenation and re –oxygenation curve
Oxygen
The saturation DO value for fresh water depends upon the temperature and total dissolved salts present in it and its value varies from 14.62 mg/L at 0oC to 7.63 mg/L at 30ºC, and lower DO at higher temperatures.
The DO in the stream may not be at saturation
(D). At this stage, when the effluent DO content of the stream starts of oxygen deficit (D) with the distance along the stream, and hence with the time of flow from the point of pollution is depicted by the Oxygen Sag Curve. The major point in sag analysis is point of minimum DO, i.e., maximum deficit. The maximum or critical (Dc) occurs at the inflexion points



Deoxygenation, reoxygenation and oxygen sag curve

De-oxygenation and Re-oxygenation
De-oxygenation curve: The time at the given temperature. he resultant curve so obtained is called Deficit, D = Saturation DO Actual DO saturation level and there may be initial oxygen deficit with

initial BOD load Lo, is discharged in to depleting and the oxygen deficit (D) increases. The (as shown in fig) of the oxygen sag curve.

Curves: curve which represents (or) showing the depletion oxygen sag on stream, the variation critical deficit of Do. Re-oxygenation Curve: In order to counter balance the consumption of D.O due to the deoxygenation, atmosphere supplies oxygen to the water and the process is called the re oxygenation.

When wastewater is discharged in to the stream, the DO level in the stream goes on depleting. This depletion of DO content is known as de-oxygenation. The rate of deoxygenation depends upon the amount of organic matter remaining (Lt), to be oxidized at any time t, as well as temperature (T) at which reaction occurs. The variation of depletion of DO content of the stream with time is depicted by the de-oxygenation curve in the absence of aeration. The ordinates below the de-oxygenation curve indicate the oxygen remaining in the natural stream after satisfying the bio-chemical demand of oxygen. When the DO content of the stream is gradually consumed due to BOD load, atmosphere supplies oxygen continuously to the water, through the process of re-aeration or re-oxygenation, i.e., along with de-oxygenation, re-aeration is continuous process.

Zones of pollution in the stream:

The self-purification process of stream polluted by wastewater discharged into it can be divided into the following four zones:

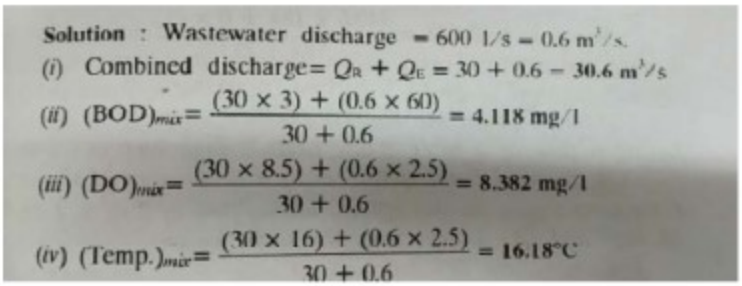
1. Zone of degradation: This zone is situated below the outfall sewer when discharging its contents into stream. In this zone, water is dark and turbid, having the formation of sludge eposits at the bottom. The DO is reduced to 40% of the saturation values. There is an increase in CO2 content and re-aeration is much slower than de-oxygenation. Though conditions are unfavourable for aquatic life, fungi at higher points and bacteria at lowerpoints breed small which stabilizes the sewage sludge. The decomposition of solid matter
takes place in this zone and anaerobic decomposition prevails.

2. Zone of active decomposition: This zone is just after the degradation zone and is marked
by heavy pollution. Water in this zone becomes greyish and darker than previous zone. The DO concentration in this zone falls down to zero. Active anaerobic organic decomposition takes place, with the evolution of methane (CH4), hydrogen sulphide (H2S), carbon-dioxide (CO2) and nitrogen (N2), bubbling to the surface with masses of sludge forming black scum. Fish life is absent in this zone and, anaerobic bacteria at the upper end and aerobic bacteria at the lower end.

However, at the end of this zone, as the decomposition slackens, reaeration sets in and DO again rises to its original level 0f 40%.

3. Zone of recovery: In this zone, the process of recovery starts, from its degraded condition to its former condition. The stabilization of organic matter takes place in this zone. Due to this, most of the stabilized organic matter settles as sludge, BOD falls and DO content rises above the 40% value. Mineralization is active, with the resulting formation of products like nitrates (NO4), sulphates (SO4), carbonates (CO3). Near the end of the zone, microscopic aquatic life reappears, fungi decreases and algae reappears.

4. Clear water zone: In this zone, the natural condition of stream is resorted with the result that Water becomes clearer and attractive in appearance,
DO rises to the saturation level, and is much higher than BOD Oxygen balance is attained.
Thus recovery is said to be complete in this zone, though some pathogenic organisms may be present in this zone.



**Solution** : Wastewater discharge $= 600\ l/s = 0.6\ m^3/s$.

(*i*) Combined discharge $= Q_R + Q_E = 30 + 0.6 = 30.6\ m^3/s$

(*ii*) $(BOD)_{mix} = \dfrac{(30 \times 3) + (0.6 \times 60)}{30 + 0.6} = 4.118\ mg/l$

(*iii*) $(DO)_{mix} = \dfrac{(30 \times 8.5) + (0.6 \times 2.5)}{30 + 0.6} = 8.382\ mg/l$

(*iv*) $(Temp.)_{mix} = \dfrac{(30 \times 16) + (0.6 \times 2.5)}{30 + 0.6} = 16.18°C$

## 4.

The influent or wastewater collected from residences or industries are first subjected to Screening process to remove the floating matters present in the sewage. The water which comes out of screening tanks is passed through the Grit chambers or Detritus tanks to remove the grits or sand particles. Then effluent which comes out of grit chamber is subjected to Primary Sedimentation tanks in order to remove the large suspended organic solids which is achieved by settling process where water is allowed to flow in slower rate, then heavy denser particles settles down at the bottom of the tank. The settled organic particles at the bottom of the primary sedimentation tanks is called primary sludge.
The effluent which comes out of the primary settling tank is subjected to Biological treatment or Secondary treatment where, decomposition of organic matter takes place by aerobic bacteria with the supply of oxygen. Then stabilized organic particles along with the water is passed through the Secondary clarifier where the stabilized organic particles settles at the bottom of the tank. The sludge which is settled at the bottom of the tank is again recirculated back and mixed with effluent which comes of primary sedimentation tank which is part of Activated Sludge Process and remaining sludgeis mixed with primary sludge and then subjected to Sludge digestion process. In sludge digestion process, wastewater is first subjected to Thickening, where number of solid sludge particles are increased by separating from liquid. The liquid which rests over the solid sludge particles are removed out is called as supernatant. The solid sludge which consists of moisture content is removed out in Dewatering process. The dry form of sludge is used as manure for improving the fertility of soil. The effluent which comes out of secondary clarifier is fed into disinfection tank where chlorine is added to the wastewater to kill germs and pathogenic bacteria's present in the water. Then water which comes out of disinfection tank containing germs are removed out in final or advanced or tertiary treatment process after that, the water can be directly discharged to nearby water courses

Screening: Screening is the first and essential step in the treatment of sewage. It consists of passing sewage through different sized screens to trap and remove comparatively large size of floating matters. If such floating matters are not removed they may damage pumps and mechanical equipment, and it will interfere with the satisfactory operation of the treatment units. Screen is device with openings generally of uniform size for removing bigger suspended or floating matters in sewage. The screening element may consists of parallel bars, gratings or wire meshes or perforated plates and the openings may be of any shape, although generally they are circular or rectangular. Screen should be situated preferably just before grit chambers, and they are housed in a chamber called screen chamber. These screens are always set in an inclined position with an angle of about 30º to 60º with vertical. This increases the effective screening surface by 40 to 100% and helps in preventing the excessive loss of head due to clogging.

This is a process for oxidizing organic matter in closed vessels in the absence of air. The process has been highly successful in conditioning sewage sludge for final disposal. It is also effective in reducing the BOD of soluble organic liquid wastes such as yeast, slaughterhouse, dairy, and paper mill waste. Generally anaerobic processes are less effective than aerobic processes, mainly because of the small amount of energy that results when anaerobic bacteria oxidize organic matter. Anaerobic processes are therefore slow and require low daily loading and long detention periods. However, since little or no power need be added, operating cost is very low. Where liquid wastes volumes are small and contain no toxic matter and there are high percentages of readily oxidized dissolved organic matter, this process has definite advantages over aerobic system. The pH in the digester must be controlled to near the neutral point.

**5.**

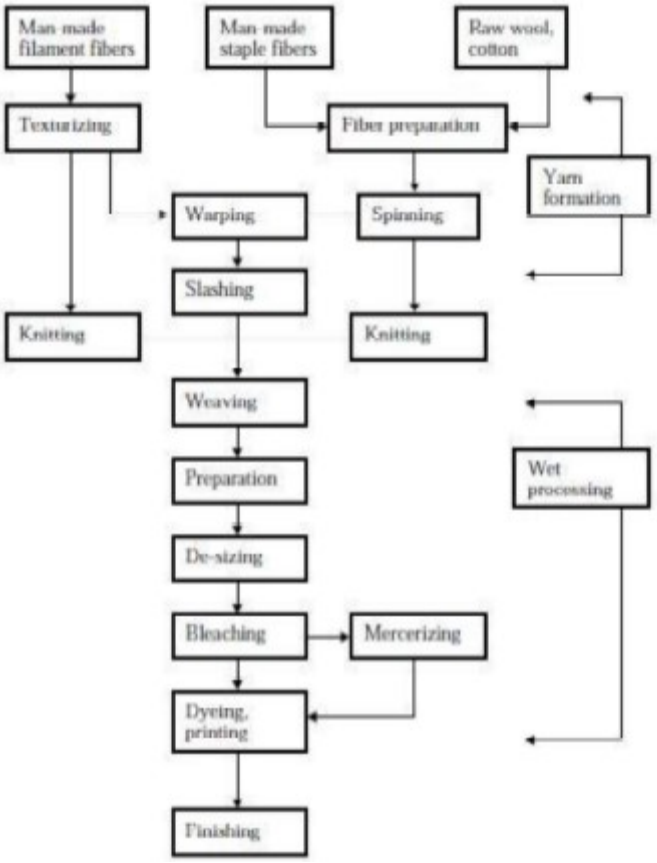
Cotton and Textile Industry

Manufacturing process An integrated cotton textile mill produces its own yarn from the raw cotton. Production of yarn from raw cotton includes steps like opening & cleaning picking, carding, and drawing spinning, winding & warping. All these sequences are dry operations and as such do not contribute to the liquid waste of the mill. The entire liquid waste from the textile mills comes from the following operation of slashing (sizing), scouring, desizing, bleaching, mercerzing, dyeing & finishing.

In slashing the yarn is strengthen by loading it with starch or other substances wastes originates from the sections due to spills & floor washings. The substitution of low BOD sizes (such as carboxy methyl cellulose) for the high BOD of the mill effluent by 40 to 90%. After slashing, the yarn goes for weaving. The prepared cloth now requires scouring & desizing to remove natural impurities and the slashing compounds. Enzymes are usually used in India to hydrolyze the starch,

acids may also be used for the is purpose. Caustic soda, soda ash, detergents etc. are also used in this section.

Bleaching operations use oxidizing chemicals like peroxides & hyper chloride to remove natural coloring material. The section contributes about 10% of the total pollution load. Mercerzing consists of passing the sloth through 20% caustic soda solution. This process includes the strength elasticity luster & dye affinity. Waste from this section is recycled after sodium hydroxide recovery. Negligible waste which may come out of this section contributes little BOD but a high degree of alkalinity.




Dyeing may be done in various ways, using different types of dyes and chemical classes of dyes include Vat dyes, developing dyes etc. color from the dyes vary widely and although these are not usually toxic, they are treated separately . Thickened dyes are used for probing and subsequent fixation. After fixation of the prints, the fabric is given a thorough wash to remove the unfixed dyes. The finishing section of the mill imparts various types of chemicals are used for various objectives. These include starches, dextrines, natural & synthetic waxes, synthetics etc. Therefore a composite waste from an integrates cotton textile. mill may include the following organic & inorganic substances starch, carboxyl methyl cellulose, sodium hydroxide, detergents, peroxides , hyperchloride dyes & pigments, sodium gums, dextrines, waxes, sulphides, soap etc. Depending on the process & predominant dye used, the characteristics of the mill waste varies widely.

The characteristic of a typical Indian cotton textile mill is given below.

Dairy Industry

With increase in demand for milk & milk products, many dairies of different sizes have come up in different places. These dairies collect the milk from the producers & then either packed it for marketing or produce different milk foods according to their capacity. Large quantity of waste water originates due to their different operations. The organic substances in the wastes comes either in the form in which they were present in milk or in a degraded form due to their processing. As such the dairy wastes though biodegradable are very strong in nature.