UNIT – V

DISPOSAL OF SEWAGE AND SLUDGE

1. Define the term "Dilution Factor"?

The ratio of the quantity of the diluting water to that of the sewage is known as the Dilution Factor.

2. What are the methods adopted for sewage disposal?

1. Dilution is disposal in water.
2. Effluent Irrigation or Broad Irrigation or Sewage forming is disposal on land.

3. What are the conditions adopted for disposal by dilution?

1. When sewage is comparatively fresh (4 to hr old) and free from floating and settlable solids.
2. When the dilution water has a high dissolved oxygen (D.O.) content.
3. When the out fall sewer of the city or the treatment plant is situated near some natural waters having large volumes.

4. What are the natural forces of purification?

1. Dilution and dispersion.
2. Sedimentation
3. Oxidation – reduction in sun-light.
4. Oxidation
5. Reduction

5. What are the factors affecting self purification of polluted streams?

a) Temperature
b) Turbulence
c) Hydrography such as the velocity and surface expanse of the river stream.
d) Adviable dissolved oxygen and the amount and type of organic matter.
e) Rate of re aeration.

6. What are the types of self purification?

The self purification divided into four zones.

1. Zone of degradation.
2. Zone of active decomposition.
3. Zone of recovery
4. Zone of Cleaner water

7. What is meant by "Self purification phenomenon"?

When sewage is discharged into a natural body of water, the receiving water gets polluted due to waste products, present in sewage effluent. The natural forces of purification such as dilution, sedimentation, oxidation – reduction in sun light go on acting upon the pollution

elements and bring back the water into its original condition. This automatic purification of polluted water, in due coarse is called the self purification phenomenon.

8. What is meant by photo synthesis?

The sun light has a bleaching and stabilizing effect of bacteria. It also helps certain micro organisms to derive energy from it and convert themselves into food for other forms of life, thus absorbing Co_2 and releasing O_2 by a process known as Photo synthesis.

9. What do you mean by Oxidation?

The oxidation of the organic matter prevent in sewage effluents, will start as soon as the sewage out falls into the river water containing dissolved oxygen. The deficiency of oxygen so created will be filled up by the atmospheric oxygen. The process of oxidation will continue till the organic matter has been completely oxidized. This is the most important action responsible for effecting self purification of rivers.

10. What do you understand by Reduction?

Reduction occurs due to hydrolysis of organic matter settled at the bottom either chemically or biologically. An aerobic bacteria will help in splitting the complex organic constituents of sewage into liquids and gases and thus paving the way for their ultimate stabilization by oxidation.

11. Define the term Re-oxygenation curve.

In order to counter – balance the consumption of D.O. due to de-oxygenation, atmosphere supplies oxygen to the water and the process is called re-oxygenation.

12. What is mean by “Oxygen sag curve”?

The amount of resultant oxygen deficit can be obtained by algebraically adding the de-oxygenation and re-oxygenation curves. The resultant curve so obtained is called the oxygen sag curve or the oxygen deficit curve.

13. Write the equation for find out the B.O.D. of the diluted water.

B.O.D. of the diluted mixture

$$C = \frac{C_s.Q_s + C_R.Q_R}{Q_s + Q_R} f$$

Where

$C_s \rightarrow$ B.O.D. of sewage

$C_R \rightarrow$ B.O.D. of river

$Q_s \rightarrow$ Sewage discharge

$Q_R \rightarrow$ Discharge of the river

14. Define the term “limnology”.

A study of the lake systems is essential to understand the role of phosphorous in lake pollution. The study of lakes is called limnology.

15. What is meant by epilimnion zone?

The water of a lake gets stratified during summers and winters. Since such turbulence extends only to a limited depth from below the water surface, the top layers of water in the lake become well mixed and aerobic. This warmer, well mixed and aerobic depth of water is called epilomnion zone.

16. What is meant by hypolimnion zone?

The lower depth of water in the lake which remains cooler, poorly mixed and an aerobic, is called are hypolimnion zone.

17. What do you understand by monocline? Give example.

The water of a lake gets stratified during summers and winters. The change from epilimnion to hypolimnion can be experienced while swimming in a lake. When you swim in top layers horizontally you will feel the water warmer and if you dive deeper, you will find the water cooler. The change line will represent monocline.

18. What are the classification of biological zones in lakes?

The most important biological zones are

(i) euphotic zone
(ii) Litt oral zone
(iii) benthic zone

19. What do you understand by “Euphotic Zone”?

The upper layer of lake water through which sunlight can penetrate is called the euphotic zone. All plant growth occurs in this zone. In deep water, algae grow as the most important plants, whole rooted plants grow in shallow water near the shore.

20. Define the term secchi dosk? Draw a neat sketch

The depth of the exphotic zone can be approximated and measured by a sample device called the secchi disk as shown in figure.

21. What do you understand by “Littoral zone”?

The shallow water near the shore in which rooted plants grow, is called the literal zone. The extent of the littoral zone depends on the slope of the lake bottom, and the depth of the euphosic zone.

22. What is meant by Behthic zone? Give example

The bottom sediments in a lake comprises what is called the benthic zone. As the organisms living in the overlying water die, they settle down to the bottom, where they are decomposed by the organisms living in the bent hic zone. Bacteria are always present on this zone.

23. Define the term “productivity of a lake”?

The productivity of a lake is defined as a measure of its ability to support a food chain. Since the algae forms the base of this food chain, which is required by the other forms of loving organisms to thrive. Its presence measures the lake productivity.

24. What are the types of lakes?

Depending upon the increasing level of its productivity the lakes may be classified as

1. Oligotrophic lakes
2. Mesotrophic lakes
3. Ecetrophic lakes
4. Senescent lakes

25. What are the requirements for disposal of Noglit soil?

1. It should be located away from the building, on the leeward side.
2. Its floor should be atleast 1.2 m above the general level.
3. Its floor should be of impervous material.
4. It should be well ventilated.

26. Give examples for soil waste?

1. garbage
2. ashes
3. rubbish
4. dust

27. What are the methods adopted for disposal of refuge?

Refuse or solid waste can be finally disposed of the following methods.

1. Controlled tipping
2. Filling of low lying areas. (Land filling)
3. Dumping into sea
4. Pulverization
5. Incineration
6. composting

28. What are the advantage of land filling methods of deposal?

1. It is simple and economical
2. No plant / equipment is required
3. There are no by products and hence there is no problem of the disposal of the by-products.
4. Separation of varies materials of the refuge is not required.

29. What are the disadvantages of land filling methods of disposal?

1. Proper site may not be available near by
2. Wind direction map not be favourable.
3. Large band areas are required.
4. It may be difficult to get large quantities of covering material.

30. What do you understand by pulverization?

In this method, the dry refuse is pulverized into power form, without changing its chemical form. The power can either be used as a poor quality manure, or else be disposed of by land filling.

31. What are the factors considered during incineration?

1. The refuge charging should be carefully observed during incineration.
2. Each batch of refuge entering furnace should be well mixed.
3. Auxiliary burners are usually installed above the refuge to ignite it and to establish the draft at the beginning of the cycle. This is all the more necessary when the moisture content of air is high.

32. What are the advantages of incineration method of disposal?

1. This is most hygienic method, since it ensures complete destruction of pathogens.
2. There is no odour trouble or dust nuisance.
3. The heat generated can be used for saving steam power.
4. Clinker produced can be used for road purposes.

33. What are the disadvantages of incineration of method of disposal?

1. Large initial expenditure.
2. Improper operation results in air pollution problems and incomplete reduction of the waste materials.
3. Disposal of the remaining residue is required.
4. High slacks needed for natural draft chimneys present safety problems.

34. What do you understand by composting?

Composting is a method in which putrescible organic matter in the solid waste / refuge is digested anaerobically and converted into humus and stable mineral compounds.

It is a hygienic method which converts the refuge into manure through the bacterial agencies.

35. What are the methods adopted for composting?

1. Composting by trenching.
2. Open window composting.
3. Mechanical composting.

36. What is meant by "humus"?

The refuge gets stabilized in about 4.5 months period, and gets changed into a brown coloured odourless innocuous powdery form known as humus, which has high manure value became of its nitrogen content.

37. Describe the term open window composting.

In this method, a large proportion of mineral matter like dust, stone, broken glass pieces etc. are first removed from the refuge. The refuge is then dumped on the ground in the form of 0.6 to 1 m high, 6 m long and 1 to 2m wide piles at about 60% moisture content. The pile is then covered with high Bool, cow dung, cattle urine etc. through which the organisms or germs that are necessary for fermentation are added after which compost is ready for use as manure when an temperature falls considerably.

38. What do you understand by mechanical composting?

The open window method of composting is very laborious and time consuming process. Also it requires large area of land which may not be available in big cities these difficulties are overcome by adopting mechanical composting in which the process of stabilization is expedited by mechanical devices of turning the compost.

39. What are the operations involved in the mechanical composting?

The operations involved in a large scale composting plant as follows:-

1. Reception of refuse
2. Segregation
3. Shredding or pulverizing
4. Stabilization
5. Marketing the humus

40. Give three important methods of disposal of sludge.

1. Sludge disposal into water.
2. Sludge disposal by application on land.
3. Sludge disposal by clogging.
4. Sludge disposal by composting.

41. What are methods adopted for sludge drying?

1. Drying the sludge on prepared sand beds.
2. Drying the sludge on centrifuges.
3. Drying the sludge by heat dryers

42. What is meant by house refuse?

This consists of vegetable and animal waste matters, ashes, cinders, rubbish, debries from cleaning and demolition of structures.

43. What is meant by organic waste?

It includes dry animal and vegetable refuse, cow dung, excreta of birds, tree leaves, sticks, plastic bottles, paper waste, rags. This waste is subject to decay with time and evolve highly offensive odour and gases which are highly detrimental to health.

44. What do you understand by inorganic waste?

This consists of non-combustible materials such as grit, dust, mud, metal pieces, metal containers, broken glass and crockery, tiles waste building material. It is not subjected to decay and is therefore not harmful to public health.

45. Define the term “Sewage sickness”.

When sewage is applied continuously on a piece of land, the soil pores or voids may get filled up and clogged with sewage matter retrained in them. The tome taken for such a clogging will, of course depend upon the type of soil and the load present in sewage.

The organic matter will thus, of course, be mineralized, but with the evolution of four gases like H_2S, Co_2, CH_4. This phenomenon of soil getting clogged is known as sewage sickness.

46. What are the types of preventive measure in adopted for sewage sickness?

1. Primary treatment of sewage
2. Choice of land
3. Under-drainage of sool.
4. Giving rest to the land.
5. Rotation of crops
6. Applying shallow depths.

47. Define the term “Raw sludge”?

The sludge, whock is deposited in a primary sedimentation talk is called Raw sludge. Raw sludge is colourous, contains highly puterscible organic matter, and is thus, very very objectionable.

48. Define the term “secondary sludge”?

The sludge, whock is deposited in a secondary clarifier is called secondary sludge. It is also put rescible, through a little less objectionable.

49. What are the unit operation / process on the sludge treatment?

Sludge treatment may include all or a combination of the following unit operations and processes

1. Thickening or concentration
2. Digestion
3. Conditioning
4. Dewatering
5. Drying
6. inconconeration

50. What is the purpose of thickening?

The purpose of thickening is to reduce moisture content of the sludge, and consequently to increase the solids concentration.

51. What are the types of thickening?

1. Gravity thickening
2. Air Floatation.
3. Centro fugation.

52. What do you mean by "Digestion"?

The principle objectives of sludge digestion is to subject the organic matter present in the settled sludge to anaerobic or aerobic decomposition so as to make it innocuous and amenable.

53. What is meant by "conditioning"?

Conditioning improves the drainability of digested sludge. Prior conditioning of sludge before application of dervatering methods renders it more amenable to dervatering.

54. What are the purpose of derveefering?

The purpose of derveefering is to further reduce the volume of sludge and thereby increase the solids concentration.

55. What are the characteristics of sources of sludge?

1. Sludge from primary settling tanks
2. Chemical precipitation
3. Trickling filter huming.
4. Activated sludge

56. Write the formula for determing the volume of sludge?

$$V_{sl} = \frac{W_s}{P_w S_{s1} P_s}$$

Where

$V_{sl} \rightarrow$ volume of sludge

$W_s \rightarrow$ wt of dry solids
$S_{s1} \rightarrow$ sp. Gravity of sludge
$P_s \rightarrow$ percent solids expressed as a decimal
$P_w \rightarrow$ density of water

(10^3 kg/m^3 at 5^o C)

57. Define the term dissolved air floatation?

Air floatation units employ floatation of sludge by air under pressure or vacuum the former process more commonly used is known as dissolved air floatation or pressure type floatation.

58. What is meant by centrifugal thicknening?

Centrifuges are used both to thicken and to dewater sludge. Their application in thicknening is normally limited to waste activated sludge.

Thickening by centrifugation involves the setting of sludge particles under the influence of centrifugal forces.

59. What are the basic types of centrifugal thickening?

The three basic types of centrifuges currently available for sludge thickening

1. Nozzle disc
2. Solids bowl
3. Basket centrifuges.

60. What are the types of digertors?

Sludge dogestors can be of two types

1. Conventional or low rate digestor
2. High rate digester

61. What are the elements involved in the design of digester?

1. Number of unit
2. Tank shape and size
3. Water depth and F
4. Roofing
5. Mixing of digester contents

62. What do you mean by Aerobic digestion?

The function of aerobic digestion is to stabilize waste sludge by long term aeration, thereby reducing the BOD and destroying volatile solids. Aerobic digestion is generally defined as a process in which micro-organisms obtained energy by endogenous or auto-oxidation of their cellular protoplasm.

63. What are the factors considered for design of aerobic digestion?

The factors that should be considered on designing an aerobic digester include

1. Defention time
2. loading criteria
3. oxygen requirement

64. What are the advantage of aerobic digestion?

1. Lower BOD concentration in digester supernatant
2. Production of odourless and easily dewaterable biologically stable digested sludge.
3. Lower capital lost

65. What are the disadvantage of aerobic digestion?

1. Higher power costs generate higher operating costs comparable with anaerobic digestion.
2. No methane gas is produced for recovery as a by-product.

66. What is meant by “Elutriation”?

Elutriation is literally a “washing” of the sludge. It is a unit operation in which a solid or a solid-liquid mixture is intimately mixed with a liquid for the purpose of transferring certain components to the liquid.

67. What are the purpose of dewatering?

1. Cost of trucking sludge to ultimate disposal site is reduced, because of reduce sludge volume consequent to dewatering.
2. Eare in handling dewatering sludge.

68. What are the methods of “elutrication”?

1. Single stage electrication
2. Multi stage electrication
3. counter current washing

69. What are the advantages of “tow stage digestion”?

1. Two stage digestion is an effective method of preventing any tendency for the sludge to short-circuit.
2. Two stage digestion offers the freedom from large slum formations in any other digestion tanks.

70. What is meant by lagoon?

The raw sludge is kept at rest in a large shallow open pond, called a lagoon.

71. Define what is meant by sludge concentrator unit?

Since the sludge obtained in a sludge digestion plant contains too much of moisture 98% to 99%) and is

therefore very bulky, may sometimes be reduced in its moisture content by first sending is to a sludge thickener unit also called a sludge concentrator unit.

72. Define the term “high rate digestion”?

The process of sludge digestion using a sludge thickener before the digestion tank, helps in reducing the capacity of the digestion tank which further reduce their capacity and the rate of digestion is also made high. Such a digestion which is used in modern large sized plants is called high rate digestion.

73.Define the term “Sludge bulking”?

The settled sludge may contain more moisture and thus resulting in the swelling of the sludge volume. This phenomenon is known as sludge bulking.

74. What are the factors assist on the development of sludge bulking?

1) Presence of harmful industrial waster waters, especially those containing high carbohydrate content antiseptic or other such properties.
2) Accumulation of sludge at the bottom of the aerofuon tanks.’

75. What are the disadvantages of sludge bulkong?

1. When sludge bulkong occurs, the sludge does not readily settle down, and is, remains in suspension in secondary clarifier is even seen in the efficient of the secondary clarifier.

2. When sludge bulkong occurs, naturally large volume of sludge will have to be handled.

76. What are the remedial measure to adopted for controlling the bulkong of sludge?

1. by heavily chlorinating the sewage
2. by increased aeration
3. by reducing the suspended solids in the sewage

77. Define the term MLSS?

The total microbial mass in the aeration system (M) is computed by multiplying the ever. Concentration of solids in the mixed liquor of the aeration tank called Mixed Liquor suspended solids (MLSS)

78. Explain the following term

1. SRT
2. MLSS
3. MCRT
4. F/M

1. SRT → Solids Retention Time
2. MLSS → Mixed liquor suspended solids
3. MCR → Mean cell Residence time

4. F/M → Food / Micro organisms

79. Define the term "sludge age"?

It is defined as the ratio between mars of suspended solids (MLSS) in the system (M) to Mass of solids leaving the system / day. It is denoted as Q_C

$$Q_C = \frac{\text{Mass of suspended solidds (MLSS) in the system(M)}}{\text{Mass of solids leaving un system / day}}$$

80. What are the methods adopted for disposed of wet digested sludge?

1. Disposed by Dumping into the sea
2. Disposed by Burial in the trenched
3. Incineration.

81. What do you understand by 'dumping'?

Dumping in an abandoned mine clearly can be resorted to only for sludges and solids that have been stabilized so that no decomposition or nuisance conditions will result. Thus method can be safely adopted for digested sludge, clean frit and incinerator residue.

82. What do you understand by "Vacuum filtration"?

Vacuum titration is the most common mechanical method of dewatering. It is used to dewater raw or digested sludges preparatory to heat treatment by vacuum filtration because the warse solids are rendered fine during digestion.

83. What do you mean by "sludge drying beds?

This method of dewatering and drying the sludge is specially suitable for those locations where temperature are higher, similar to the one prevailing in our country. The method consists of applying the sludge on specially prepared open beds of card.

84. Give Brief notes on sludge Lagooning ?

A Lagoon is a shallow earth basin into which untreated or digested sludge is deposited. Untreated – sludge lagoons stabilize the organic solids by an aerobic and aerobic decomposition, which may give rise to objectionable odours. Hence the lagoons should be located away from the town.

85. What do you understand by "chemical conditioning"?

Chemical conditioning is the process of adding certain chemicals to enable coalescence of sludge particle facilitating easy extraction of moisture.

Exp: Alum, ferric, chloride, lime.

86. Write the expression for determining the capacity of digester in parabolic shape?

$$V = \left[V_f - \frac{2}{3}(V_f - V_d) \right] T_1 + V_d T_2$$

Where

v → volume of digester
v_f → volume of fresh sludge added per day
v_d → volume of digested sludge withdrawn per day
T_1 → digestion time in days
T_2 → mooning storage in days

87. Write the expression for determining the capacity of digester in linear?

$$V = \frac{V_f + V_d}{2} T_1 + V_d T_2$$

88. What do you understand y temp of digestion?

Digestion of sludge in temperature dependent. Here, rate of digestion increases with increase in temp upto a temp of 40°C the digestion is brought about by a particular type of organisms.

While a totally different type of organisms establish in the digester at temp higher than 45°C. The former range is called the mesospheric range and the latter is known as Thermopolis range.

89. What are the factors depends upon the capacity of digester?

The capacity of digester, depends on

(i) Daily volume and moisture content of input sludge and digested sludge
(ii) Temperature of digestion
(iii) Desired degree of destruction of volatile solids
(iv) Storage capacity of for digested sludge.

90. What do you understand by Daily volume and moisture content of sludge?

The volume of daily sludge verves depending upon degree of removal of suspended solids in primary and final setting links, moisture content and sp. Graving of sludge.

91. What are the purpose of sludge concentration?

1. To permit increased loadings to sludge digesters
2. To increase feed solids concentration of vacuum filters
3. To economize on transport costs as in ocean barging incase of raw sludge.

UNIT – B

1. Enumerate the two general methods adopted for sewage disposal and explaining the conditions favourable for their adoption.

There are two general methods of disposing of the sewage effluents.

a. Dilution is disposal in water.
b. Effluent Irrigation or Broad Irrigation or sewage farming is disposal on land.

Disposal by dilution:-

Disposal by dilution is the process whereby the treated sewage or the effluent from the sewage treatment plant is discharged into a river stream, or a large body of water, such as a lake or sea. The discharged sewage in due course of time, is purified by what is known as self purification process of natural waters. The degree and amount of treatment given to raw sewage before disposing it of into the river stream in question, will definitely depend not only upon the quality of raw sewage but also upon the self purification capacity of the river stream and the intended use of its water.

Conditions favouring Disposal by dilution.

The dilution methods for disposing of the sewage can favourably be adopted under the following conditions.

1. When sewage is comparatively fresh (4 to 5 hr old) and free from floating and settleable solids. (or are easily removed by primary treatment)
2. When the diluting water (is the source of disposal) has a high dissolved oxygen (0-0) content.
3. Where diluting waters are not used for the purpose of navigation or water supply for at least some reasonable distance on the downstream from the point of sewage disposal.
4. Where the flow currents of the diluting waters are favourable, causing no deposition, nuisance or destruction of aquatic life.
5. When the out fall sewer of the city or the treatment plant is situated near some natural water having large volumes.

Disposal on land:-

Disposal of Sewage Effluents on land for Irrigation:

In this method, the sewage effluent (treated or diluted) is generally disposed of by applying it on land. The percolating water may either soon the water table or is collected below by a system of under drains. This method can then be used for irrigating crops.

This method, in addition to disposing of the sewage may help in increasing crop yields (by 33% or so) as the sewage generally contains a lot of fertilizing minerals and other elements.

However, the sewage effluent before being used as irrigation water, must be made safe. In order to lay down the limiting standards for sewage effluents, and the degree of treatment required, it is necessary to study as to what happens when sewage is applied on to the land as irrigation water.

The pretreatment process may be adopted by larger cities which can afford to conduct treatment of sewage when sewage is diluted with water for disposal for irrigation, too large volumes of dilution water are generally not needed, so as not to require too large areas for disposal.

2. The sewage of a town is to be discharged into a river stream. The quantity of sewage produced per day is 8 million litres, and its BOD is 250 mg/l. If the discharge in the river is 200 l/s and if its BOD is 6 mg/l. find out the B.O.D. of the diluted water.

Solution:-

Sewage discharge = Q_s

$$= \frac{8 \times 10^6}{24 \times 60 \times 60} \text{ l/s}$$

$$= 92.59 \text{ l/s}$$

Discharge of the river = Q_R

= 200 l/s

B.O.D. of sewage = C_s = 250 mg/l.
B.O.D. of river = C_R = 6 mg/l.
B.O.D. of the diluted mixture

$$= C = \frac{C_s.Q_s + C_R.Q_R}{Q_s + Q_R}$$

$$= \frac{250 \times 92.59 + 6 \times 200}{92.59 + 200}$$

$$= 83.21 \text{ mg/l}$$

3. In the above problem, what should be the river discharge, if it is desired to reduce the B.O.D. of diluted water to 20 mg/l.

Solution:-

Here C = 20 mg/l
B.O.D. of the diluted mixture

$$C = \frac{C_s Q_s + C_{12} Q_{12}}{Q_s + Q_R}$$

$$20 = \frac{250 \times 92.59 + 6 \times Q_R}{92.59 + Q_R}$$

$$20\ (92.59 + Q_R) = 250 \times 92.59 + 6Q_R$$

$$20 \times 92.59 + 20Q_R = 250 \times 92.59 + 6Q_R$$

Q_R = 1521 l/s

4. A city discharges 1500 lit per second of sewage into a stream whose minimum rate of flow is 6000 lit/sec. The temperature of sewage as well as water is 20îC. The 5 day B.O.D. at 20îC for sewage is 200 mg/l and that of river water is 1 mg/l. The D.O. content of sewage is zero, and that of the stream is 90% of the saturation D.O. if the minimum D.O. to be maintained in the stream is 4.5 mg/l, find out the degree of

sewage treatment, required. Assume the de-oxygenation coefficient as 0.3

Solution:-

From the table given at the end of the book, the value of saturation D.O. at 20°C is found out as 9.17 mg/l

D.O. Content of the stream

= 90% of the saturation D.O

$$= \frac{90}{100} \times 9.17$$

$$= 8.25 \, mg/l$$

D.O of mix of the start point is at t = 0

$$= \frac{8.25 \times 6000 + 0 \times 1500}{6000 + 1500}$$

$$= 6.6 \, mg/l$$

DO = initial DO deficit

= [saturation D.O at mix temp – D.O. of mix]

= 9.17 – 6.6 = 2.57 mg/l

(Assuming instances mixing]

Minimum DO to be maintained in the stream

= 4.5 mg/l Maximum permissible saturation deficit (i.e critical DO deficit)

DC = 0.17 – 4.5
=4.67 mg/l

Now, using equation the first stage BOD of mixture of sewage and stream (L) is given by

$$\left[\frac{L}{D_c f}\right]^{f-1} = f\left[1-(f-1)\frac{D_o}{L}\right]$$

$$D_o = 2.57 \, mg/l$$

$$D_L = 4.67 \, mg/l$$

$$f = \frac{kR}{kD} = \frac{0.3}{0.1} = 3$$

We get

$$\left[\frac{L}{4.67\times 3}\right]^{3-1} = 3\left[1-(3-1)\frac{2.57}{L}\right]$$

$$\left[\frac{L}{14.01}\right]^{2} = 3\left[1-\frac{5.14}{L}\right]$$

Solving by hit & travel we get the value

L = 21.1 mg/l

New Using

$$Y_t = L\left[1-10^{-K_D.t}\right]$$

Maximum permissible 5 day BOD of the mix (at 20°C)

$$Y_5 = 21.1\left(1-10^{0.1\times 5}\right)$$

$$\left[\text{Where } K_D \text{at} 20°C = 0.1\right]$$

$$= 14.43\ mg/l$$

Now, using equation

$$C = \frac{C_S Q_S + C_R G_R}{Q_S + G_R}$$

C stands for concentrations of BOD

$$14.43 = \frac{C_S \times 1500 + 1\times 6000}{1500+6000}$$

Where C_s will represent the permissible BOD_5 (at 20°C of course of the discharged waste water)

Solving, we get

C_s = 68.16 mg/l

Degree of treatment regd (%)

$$= \frac{\text{Original BOD of sewage-Permissible BOD}}{\text{Original BOD}}$$

$$= \frac{200-68.16}{200} = 65.9\%$$

5. A city discharges 100 cumecs of sewage into a river, which is fully saturated with oxygen and flowing at the rate of 1500 cumecs during it's lean days with a velocity of 0.1 m/s. The 5 – days BOD of sewage at the given temp is 280 mg/l. Find when and where the critical D.O deficit will occur in the down stream portion of the river and what its amount is, assume coefficient of purification of the stream (f) as 4.0, and coefficient of de – oxygenation (K_D) as 0.1

Solution:

The initial D.O of river

= saturation D.O at the given temp
= 9.2 mg/l (say)

D.O of mix at t = 0 is at start

$$= \frac{9.2 \times 1500 + 0 \times 100}{1500 + 100}$$

$$(\text{assuming that D.O of sewage is nil})$$

$$= 8.62 \, mg/l$$

Initial D.O deficit of the stream

=D.O = 9.2 – 8.62 = 0.58 mg/l

Also, 5 – day BOD of the mixture of sewage and stream is given by

$$C = \frac{C_S Q_S + Q_R C_R}{Q_S + Q_R}$$

$$= \frac{280 \times 100 + 1500 \times 0}{100 + 1500}$$

$$= \frac{280 \times 100}{1600}$$

$$= 17.5 \, mg/l$$

5 day BOD of mix at the given temp

Y_5 = 17.5 m/l

The ultimate BOD of the mix is L

$$= \frac{17.5}{0.684} = 25.58 \, mg/l$$

Now using

$$\left[\frac{L}{DC.f}\right]^{f-1} = f\left[1-(f-1)\frac{Do}{L}\right]$$

$$\left[\frac{25.58}{D_c \times 4}\right]^3 = 4\left[1-\frac{3 \times 0.58}{25.58}\right]$$

$$D_C = 4.12 \, mg/l$$

Now, from equation

$$t_c = \frac{1}{K_D(f-1)} \log_{10}\left[f\left\{1-(f-1)DO/L\right\}\right]$$

$$t_c = \frac{1}{0.1(4-1)} \log_{10}\left[4 \times 1 - \frac{3 \times 0.58}{25.58}\right]$$

$$= \frac{1}{0.3} \times 0.571 = 1.905 \text{days}$$

Now, distance = Velocity of river x Travel lime

= 0.1 m/s x (1.905 x 24x 60x 60 sec)

= 16, 460 m

= 16.46kN

Hence the most critical deficit will occur after 1.905 days and at pt 16.46 km down stream of the pt of sewage disposal.

6. A Town with a population of 30,000 has to design a sewage treatment plant to handle industrial as well as almost waste waters of the town. A sanitary survey revealed the following:

Dairy waster of 3 million lit/day with BOD of BOD mg/l and sugar mill waste of 2.4 million lit/d with BOD of 1500 mg/l are produced. In addition domestic sewage is produced of the rate of 240 lit/ca/d. The per capita BOD of domestic sewage being 72 gm/d. An overall expansion factor of 10 percent to be produced. The sewage effluents are to be discharged to a river stream with a minimum dry weather flow of 4500 lot / sec and a saturation dissolved oxygen content of 9 mg/s. It is necessary to maintain a dissolved oxygen content of 4 mg/l in the stream. Determine the degree of treatment regd to be given to the sewage. Assume suitable values of coefficient of de-oxygenation and re – oxygenation.

Solution:

Per Capital BOD of the domestic sewage

= 72 gm/day
= 72 x 1000 mg/d

The per capita sewage produced

= 240 lit/d

BOD per lit of the domestic sewage

$$= \frac{72 \times 1000}{240} \text{ mg/l}$$
$$= 300 \text{mg/l}$$

Amount of domestic waste water produced per day

= 30,000 x 240 lit
= 7.2 million lit

Net BOD of all waste waters (i.e domestic _+ industrial)

$$= \frac{7.2 \times 300 + 3 \times 1100 + 2.4 \times 1500}{7.2 - 13 + 2.4}$$
$$= 719 \text{ mg/l}$$

Total waste water discharge

$$= \frac{\text{Vol of waste waters entering /day}}{\text{No of sec in 1 day}}$$

$$= \frac{3ML + 2.4ML + 7.2ML}{1 \times 24 \times 60 \times 60 \sec}$$

$$= \frac{12.6 \times 106}{24 \times 3600} l/s$$

$$= 145.8\ l/s$$

Total waste water discharge with 10% expansion factor

= 1.1 x 145.8 l/s = 160 l/s

Initial DO of saturated stream water

= 9 mg/s (i.e saturation D.O as given)

DO of mixture of t = 0 is at start pt

$$= \frac{\text{D.O of river} \times Q_R + \text{DO of sewage} \times Q_s}{Q_R + Q_S}$$

$$= \frac{9 \times 4500 + 0 \times 160}{4500 + 160}$$

(Assuming that the bio of water wafers on N.o1)
=8.69
initial b.o defliot =Do=9-8-69
(assuming instaneous having
=0.31mg/l.

Also, critical D.o deflect is allowable max D.o deflect =Dc
= 9-4-0=5mg/l
Now, using equ.

$$\left(\frac{L}{Dcf}\right)^{f1} = f\left[1-(f-1)\frac{Do}{L}\right]$$

where Dc→ 5mg/l
Do → 0.31mg/l
KD=0.1KR=0.3 f=3
(assumed values of mix temp)

$$\left(\frac{t}{5x3}\right)^{2} = 3\left[1-\frac{2x0.31}{L}\right]$$

solving by not and trial

l=26.65mg/l

max, permissible 5 day B.O.D of max at max

temp=y_5=L[1-(1-0)$^{-0.1x5}$] ten at max temp is assumed =0.1.

=0.684L
=0.684x25.65
=17.54mg/l

using equ

$$C = \frac{C_s Q_s + C_R Q_R}{Q_S + Q_R}$$

$$17.54 = \frac{C_S x160 + 0x4500}{160 + 4500}$$

C_s → maxi permissible $B.O.D_5$ of waste waters.
C_s = 510.99mg/l

Initial B.O.D of coty waste waters
=719mg/l

∵ Degree of treatment required.

$$= \frac{719\text{-}510.99}{719}$$

=28.93%

7. In the previous prob determine what should be as direction ration if no treatment was required. And thus determine the over dk change for such as condition.

Solution:

When no treatment is required. The value of max. permissible Bon^5 of waste water is C_s should be 719, Q_R can then be determined as

$$17.54 = \frac{719x160 + 0xQ_R}{160 + Q_R}$$

$$17.54\left[160 + Q_R\right] = 719x160$$

$$160 + Q_R = \frac{719x160}{17.54} = 6559$$

$$Q_R = 6399 l/s(ray)$$

Dilution ratio= $\frac{6399}{160} = 399.99$say

40times.

Hence when the dilution ration is 40 and the minimum river dos charge is 6400 l/s, no treatment will be required.

8. A waste water efficient of 560 l/s wo/u a BOD =50mg/l Do=3.0mg/l and tempof 23^0C enters a river where the flow is 28 m^3/sec, and BOD =4.0mg/l and temp of 17^0c k_1 of the waste is 0.10/ day at 20^0C. The vel of water in the river down stream is 0.18m/s and depart of 1.2m. determine the following after moving of waste water in the low over water;
i) combined discharge
ii) BOD
iii) Do and
iv) Temperature

Solution:-

Particulars of sewage particulars of River
Thrown

Q_s=560 c/s Q_R=28 m^3/sec
=0.56m^3/sec

Concentration(cs) Concentrations (CR)

Bon=50mg/l BoD=4.0mg/l
Do=3.0mg/l Do=8.2mg/l
Temp=23^{0}C Temp=17^{0}C

K_1 at 20^0=0.1 perday

i) combined discharge =9s+9R
=0.56+28
=28.56m^3/sec

Now, using equ

$$C = \frac{C_s Q_s + C_R Q_R}{Q_S + Q_R}$$

(ii) BOD of max

$$= \frac{50x0.56 + 4.0x28}{0.56 + 28}$$

$$= \frac{140}{28.56} = 4.9mg/l$$

(iii) Do of mix

$$= \frac{3.0x0.56 + 8.2x28}{0.56 + 28}$$

$$= 8.098mg/l$$

(iv) temp of max

$$= \frac{23x0.56 + 17x28}{0.56 + 28}$$

17.12^{0}C

9. 125 ciemecs of sewage of a city is discharged in a perennial river which is fully saturated with oxygen and flows at a minimum rate of 1600 ciemecs with a minimum velocity of 0.12 m/s if the 5 day BOD of the sewage is 300mg/l final out where the oritual do will occur in the river assume.

i) the co efficient of purification of the river at 4.0
ii) The coefficient of Do as 0.11
iii) The ultimate BOD as 125% of the 5 day BOD of the mixture of sewage and river water.

Solution:

Assume saturation D.O concentration. Of the given river D_s=9.2

The D.o of the river at the mixing Dt after disposal of Sewage

$$= \frac{125x10 + 1600x9.2}{125 + 1600}$$

$$= 8.53mg/l$$

Initial D.O. default (DO)=DS-D

=9.2-8.53
=0.67mg/l

Bon_5 of the river at the mixing pt after disposal of sewage y_5

$$= \frac{125x300 + 1600x0}{125 + 1600}$$
$$= 21.74 mg/l$$

The ultimate BoD of river (max) at moving
Pt(L) = 125%BOD
=125x21.74=27.17mg/l
Noco using equ

$BOD_5=L[1-(10)^{-kdx5}]$
$21.74=27.17[1-(10)^{-kdx5}]$
$0.8=[1-(10)^{-kdx5}]$

$(10)^{-5KD}=0.20$
$-5KDlog10=log0.20$
$KD=0.14$

The coefficient of DO or BOD (KD) Is given in assumption NO. (ii)m to be 0.11 as against its value of 0.14 computed above on the basis of assumption (iii) Even finally there is some in consistency in the given data, and the examiner should have given only one of the two assumption is either ii) or iii) which would have suffice purpose.

Under such difficult situation, 10e may solve the question by using both the values of KD is 0.11 as well as 0.14. The KD value of 0.14 will, displace the critical pt upstream and will thus provide more conservative design values.

Case (1) :- when $K_D=0.11$

$$t_c = \frac{1}{k_D(f-1)} \log\left[\left\{1-(f-1)\frac{Do}{L}\right\}f\right]$$
$$t_c = \frac{1}{0.11(4-1)} \log\left[\left\{1-(4-1)\frac{0.67}{27.17}\right\}x4\right]$$
$$= 1.723$$

The distance along the river, where the critical
F.O. defilit will occur =S=velocity x time
=0.12m/s x1.723x24x3600sec.
=17.86km sat 18jn

Hence, critical D.O. difficult will occur at is km down stream of the sewage disposal pt

Case(2) : when KD=0.14

$$t_c = \frac{0.11}{0.14} x1.723 = 1.354 days$$
$$S = 17.86x\frac{1.354}{1.723} = 14.04km$$

Hence, critical D.O. difficult will occur at 14km downstream of sewage disposal pt.

10. A treated waste water is discharged at the rate of 1.5 m^3/s into a river of minimum 710 to 5m^3 /sec. The temperature of river flow and waste water flow may be assumed at 25^{0}C The BOD removal rate constant k is 0.12/d (base 10) . The BOD_5 at 25^{0}C of the waste water is 200 mg/l and that of the river water upstream of the waste water out full is 1mg/l. the efficiency of waste water treatment is 80% Evaluate the following.

i) BOD_5 at 25^{0}C if river water received un treated waste water.

ii) BOD_5 at 25^{0}C if river water recieves treated waste water.

Solution:

Discharge of waste water = Q_w=1.5m^3/s
Discharge or river =Q_n5m^3/s
Temperature =T=25^{0}C
KD(25^0)=K_1=0.12/d

CW-conc of BOD_5 for untreated water
Water =200mg/l

C_R-conc. Of BOD_5 for river water =1/mg/l

(i) conc of BOD_5 of the maxture if un treated waste water is dischargd into we river

$$C = \frac{C_w Q_w + C_R Q_R}{Q_w + Q_R}$$
$$= \frac{200x1.5 + 1x5}{1.5 + 5}$$
$$= 46.92 mg/l$$

(ii) BOD^5 of the treated waste water is given by c+w=20% of the BOD^5 of un treated waste water

(li efficiency of waste water treatment a 80%)
=20% x CW
=20% x200 mg/l
=40mg/l
BOD^5 of mixture if treated waste water is discharged into the river

$$C^1 = \frac{C_{TW}.Q_W + C_R.Q_R}{Q_W + Q_R}$$
$$= \frac{40x1.5 + 1x5}{1.5 + 5}$$
$$= 10 mg/l$$

11. In impervious prob(40) found out the ultimate BOD of the river water after is receives treated waste water.

BOD_5 of river water after is receives treated waste water

=10mg/l (as computed above prob (10))

ultimate BOD of this mixture

$=y_u=C=?$

Using equ

$Y_t(day) = L[1-(10)^{-kp.t}]$

$Y_5=L[1-(10)^{-0.12x5}]$

$10=L[1-(10)^{-0.6}]$

L=13.35 mg/l

12. A town having population of 40,000 disposes sewage by label treatment. It gets a per copier assured water supply from water works at a rate of 130«d. assuming that the land used for sewage disposal can absorb 80m^3 of sewage per her per day, determine the lanel area reqd and (t) cost at the rate of Rs./ 25,000 per thee make suitable assumptions where needed.

Solution:

Population =40,000

Rate of water supply =130 c/d/per

Total water supplied per day

=40,000x130l

=52,00,000lot

=5,200cu.m.

Assuming that 80% of this water appears as sewage, we have

The quantity of sewage produced per day

=0.8x5200

=4160 cu.m

Area of land reqd for disposing sewage

$$=\frac{4160}{80}52\text{hect}$$

providing 50% extra land for rest and rotation, we have

the total land area reqd.

=1.5x52

=78hect.

Cost of lanel involved = Rs25,000x78

=Rs. 19,50,000

13. A Town disposes sewage by lanel treatment. It has a sewage farm of area 150 hect. The area included an extra provision of 50% for rest and rotation the population of the town being 50,000 and rate of water suppy 140 lot/ capila / day. If 75% of the water is converted into sewage determine the consuming capacity of the soil.

Solution:

Quantity of water produced per day

=50,000x140 lit/d

=70,00,000 l/d

=7,000 cu. m/d.

Quantity of sewage produced

=0.75x7000
=5,250 cu. m/d.

Area of farm land provided

=150 hec worth 50% additional reserve

Area provided for immediate need

$$\frac{150}{1.5} = 100\text{hect}$$

100 hect is capable of passing 5250 cum/d

$\therefore$ consuming capacity of 800%

$$= \frac{5250}{100}$$
$$= 52.5\text{cu.mhe/d}$$

14. Write short notes on
i) Efficient irrigation and sewage farming.
ii) sewage sickness.

Efficient irrigation and sewage for morning:

Although, out wardly, both these terms are used as synonyms to each other, yet there is one basic difference b/w the. This difference is that : in “efficient irrigation” (or broad irrigation), the chief consideration is the successful disposal of sewage, while in sewage farming, the chief consideration in the successful growing of the crops.

Hence in broad irrigation, the raw or settled. Sewage is discharged on vacant land which is provided under neath with a system of properly laid under – drains. These under –drains basically consist of 15 to 20 cm river process tile pipes, load open founded at a spacing of 12 to 30m. The efficient collected in these drains after getting filtered through the 5001 pores is a generally small (as a large quantity gets evaporated) and well stabilized, and can be early disposal into some natural water courses, with out any further treatment.

In case of sewage farming, however the tress is load upon the use of sewage efficient for irrigation crops and increasing the fertility of the soil. The pre-treatment of sewage in removing the ingredients which may prove harmful and toxic to the plant is there fore, necessary in this case.

Sewage sickness:

When sewage is applied continuously once. Piece of land, the soil pores or void may get filled up and clogged with sewage matter retained in them. The time taken for such a clogging will, of course depend upon the type of $001 and the load prevent in sewage. But when once these voids are clogged, free circulation for air will be prevented and anaerobic conditions will develop coottion the pores. Due to those the aerobic de composition of organic matte will stop, and anaerobic decomposition will start. The organic matter will there, of course, be miner lord but with the evolution of foul gases live H_2S, CO_2,

CH_4. this phenomenon of soil getting clogged is known as sewage sickness of land.

15. What are the preventive measure of sewage sickness by the land disposal? Describe it.

In order to prevent the sewage sickness of a land, the following preventive measures may be adopted.

1. Primary treatment of sewage.
2. Choice of land
3. under drainage of soil
4. Giving rest to the land.
5. Rotation of crops
6. Applying shallow depths.

Primary treatment of sewage.

The sewage should be disposed of, only after primary treatment, such as screening, grit removal and sedimentation. This will help in removing settle able solids and reducing the B.O.D load by 30% or so. And as such, soil pores will not get clogged, quickly.

Choice of land:

The piece of land used for sewage disposal should normally be sandy or loamy, dayey lands should be avoided.

Under – drainage of soil:

The cannel on which un sewage is being disposed of, can be better drained if a system of under – drains (ie open joined proper) is laid below, to collect the efficient; and those will also minimize the possibilities of sewage sickness.

Giving rest to the land:

The land which the sewage being used for disposal should be given rest, periodically by keeping some extra land as reserve and stand-by for diverting the sewage during the period the first land is at rest more over, during the rest period, the land should be thoroughly planned so that it gets broken up and aerated.

Rotation of crops;

Sewage sickness can be reduced by planting different crops in rotation instead of growing single type of a crop. This will help in utilizing the fertilizing elements of sewage and help on aeration of soil.

Applying shallow depths:

The sewage should not be filled over the area in large depth, but it shocked be approved in this layers. Greater depth of sewage on a land does not allow the soil to receive the sewage satisfactory and ultimately results in it clogging.

Sewage –sick land can be improved and made useful by thoroughly plugging and treating the soil, and exposing it to the atmosphere.

16. A sedimentation tank is treating 4.5 million lit of sewage per day containing 275 ppm of suspended solids. The tank removes 50% of suspended solids. Calculated the quantity of sludge produced per day in bulk and lot if (a) moisture content of sludge is 98%

Solution:

Volume of sewage treated
= 4.5 M.Lit / day

Since suspended solids amount to 275 mg / 2, we have that wf of suspended solids present in sewage

$$= \frac{275 \times 4.5}{106} \times 10^6 \text{ kg/d}$$

$$= 1237.5 \text{ kg/d}$$

Since 50% of solids are removed in sedimentation tank, we have the wt of solids removed in sedimentation tank

$$= 1237.5 \times \frac{50}{100}$$

$$= 618.75 \text{ kg/d}$$

(a) When moisture content of sludge I s98% then 2 kg of solids (dry sludge) will make

= 100 kg of wt sludge

$\because$ 618.75 kg of solids (dry sludge) will make

$$= \frac{100}{2} \times 618.75$$

$$= 30937.5 \text{ kg} \approx 30940 \text{ kg}$$

Hence wet sludge or sludge produced per day

=30, 940 kg $\approx$ 30.94 ton

Assuming the specific gravity of wet sludge (sludge) as 1.02, we have unit wt. of sludge

$$= 1.02 \times 1 \text{ t/m}^3$$

$$= 1.02 \text{ t/m}^3$$

$$\left[\because \text{unit wt of water} = 1 \text{ t/m}^3\right]$$

$\because$ volume of wet sludge produced per day

$$= \frac{\text{wt}}{\text{unit wt}} = \frac{30.94}{1.02} = 30.33 \text{m}^3$$

Vol. of sludge (when its m.c. is 98%)

= 30.33 cu.m

17. In the same prob (1) Finding out the moisture content of sludge is 96%.

When moisture content is 96% then

4 kg of solids will make

= 100 kg of wet sludge

$\because$ 618.75 kg of solids will make (Refer previous prob)

$= \frac{100}{4} \times 618.75$ kg of wet sludge

$= 15468.75$ kg of wet sludge

$= 15,470$ kg (say) of wet sludge

=15.47 tonnes of wet sludge

Hence, wt. of, sludge (when its m,c, is 96%)

= 15.47 tonnes

if sp – gravity of sludge is 1.02 then

Volume of sludge (when its m,c, is 96%)

$= \frac{15.47}{1.02} m^3$

$= 15.17 m^3$

Hence, the vol. of sludge at 96% m.c.

= 15.17 cu.m

18. There is a sewage sludge with volume containing a certain moisture content P_1 (%) what will be the volume of this sludge if its moisture content is reduced to P.(%)

Solution:

Let the given sewage contains soids = w kg. let its volume to v_1 at a moisture content of p_1(%) and v at a moisture content of p(%).

At moisture content of P_{11} we have

$(100 - P_1)$ kg of solids will make

w kg of solids will make

$= \frac{100.w}{(100 - P_1)}$ kg of wet sludge

or wt. of sludge produced

$= \frac{100.2}{(100 - p_1)} kg$

if r_2 is the unit wt of sludge in kg / m^3, then vol of sludge produced $= \frac{100.w}{(100 - p_1)} . \frac{1}{r_S} m^3$

$V_1 = \frac{100.w}{100 - P_1} . \frac{1}{r_S}$

At moisture content of P(%), similarly, we have vol. of sludge produced (v)

$$= \frac{100.w}{100-P}.\frac{1}{r_s} m^3$$

$$r = \frac{100.w}{100-P}.\frac{1}{r_s}$$

From equation

$$w = \frac{(100-P_1)v_1.v_s}{100} \quad ....(1)$$

$$w = \frac{(100-P)v.v_s}{100} \quad ....(2)$$

Equating (1) & (2)

$$\frac{(100-P_1)v_1v_s}{100} = \frac{(100-P)v.v_s}{100}$$

$$\boxed{v = v_1\left[\frac{100-P_1}{100-P}\right]}$$

19. The moisture content of a sludge is reduced from 95 to 90% in a sludge digestion tank. Find the percentage decrease in the volume of sludge.

Solution:-

Using equation

$$v = v_1\left[\frac{100-P_1}{100-P}\right]$$

$$v = v_1\left[\frac{100-95}{100-90}\right]$$

$$= v_1 \times 5/10$$

$$= \frac{v_1}{2}$$

Thus, the volume at 90% moisture will be half of that at 95% moisture. Hence the percentage decrease in moisture will be 50%.

20. Design a digestion tank for the primary sludge with the help of following data:

- **(i) Average flow = 200 mcd**
- **(ii) Total suspended solids in raw sewage = 300 mg /l**
- **(iii) Moisture content of digested sludge = 85%**

Assume any other suitable data you require

Solution:

Average sewage flow = 20 m.c.d

Total suspended solids = 300 mg / l

$\therefore$ wt of suspended solids in 20 Mc of sewage flowing per day $= \dfrac{300 \times 20 \times 10^6}{10^6}$

= 6000 kg / 1 day

Assuming that 65% solids are removal on primary settling tanks, we have wt of solids removed in the primary settling tank

$= 65\% \times 6000 \text{ kg/d}$

$= 3900 \text{ kg/d}$

Assuming that the fresh sludge has a m,c, of 95% we have 5 kg of dry solids will make = 100 kg of wet sludge

and 3900 kg of dry solids will make

$\dfrac{100}{5} \times 3900 \text{kg}$ of wet sludge per day

Assuming sp – gravity of wet sludge as 1.02

i.e. unit wt = 1020 kg / m^3, we have

the volume of raw sludge produced / day

$= v_1 = \dfrac{78000}{1020} m^3/d$

$= 76.47 m^3/d$

The volume of the digested sludge (V_2) at 85% m.c. is given by the formula

$$v_2 = v_1\left[\frac{100 - P_1}{100 - P}\right]$$

$$v_2 = v_1\left[\frac{100 - 95}{100 - 85}\right]$$

$$v_2 = v_1(5/15) = \frac{1}{3} \times v_1$$

$$= \frac{1}{3} \times 76.47 \text{ m}^3/\text{d}$$

$$\boxed{v_2 = 25.49 \text{ m}^3/\text{d}}$$

Now, assuming the digestion period as 30 days, we have capacity of the reqd digestion tank, given by equation

$$\text{capacity} = \left[v_1 - \frac{2}{8}[v_1 - v_2] \right] t$$

$$= 76.47 - \frac{2}{3}[76.47 - 25.49]30$$

$$= \left[76.47 - \frac{2}{3} \times 50.98 \right] 30$$

$$= 1274.5 \quad \square\ 1275\ m^3$$

Now, providing 6.0m depth of the cylindrical digestion tank, we have

$$\text{c/s area of the tank} = \frac{1275}{6}$$

$$= 212.5\ m^2$$

$$\varphi \text{ of tank} = \sqrt{\frac{212.5}{14}} = 16.45 \square\ 16.5m$$

Hence provide cylindrical sludge digestion tank 6m deep $\times$ 16.5 m φ, with additional hoppered bottom of 1% slope for collection of digested sludge.

21. Raw waste water is entering a treatment plant and contains 250 mg / l suspended solids. It 55% of these solids are removed in sedimentation.
(a) Find the volume of raw sludge produced per million litre of waste water. Assume that the sludge has a moisture content of 96% and specific gravity of solids is 1.2.

(b) Find the unit weight of raw sludge

(c) If 45% of raw sludge is changed in liquid and gas in the digestion tank, find the volume of digested sludge per million litre of waste water. Assume that the moisture constant of the digested sludge is 90%.

Solution:

(a) Suspended solids in waster water = 250 mg / 2

Since 55% of these solids are removed in sedimentation, we have

The solid removed in sedimentation as sludge

= 55% $\times$ 250 mg / l
= 137.5 mg / l

If volume of waste water is 1 million litre, then solids removed as sludge

$$= \frac{137.5}{10^6} \times 10^6 \text{ kg}$$

$$= 137.5 \text{ kg}$$

Sludge produced will, thus, have 137.5 kg solids, and rest will be water. Now, since the moisture constant of

sludge is 96%, we have 4 kg of solids will produce 100 kg of wet sludge, by joining with 96 kg of water.

$\therefore$ Water contained in 4 kg of solids

= 96 kg

$\therefore$ Water contained in 137.5 kg of solids

$$= \frac{96}{4} \times 137.5$$
$$= 3300 \text{ kg}$$

Hence volume of sludge produced per million litre of water

$$= \frac{\text{Weight of solids}}{\text{unit wt. of solids}} + \frac{\text{wt. of water}}{\text{unit wt. of water}}$$
$$= \left[\frac{137.5}{1.2 \times 1000} + \frac{3300}{1000} \right] \text{cu.m}$$

$\left(\because \text{unit weight of solids} = \text{sp. gravity of solids} \times \text{unit wt. of water} = 1.2 \times 1000 \text{ kg/ m}^3 \right)$

$$= 0.115 + 3.3$$
$$= 3.415 \text{ cu.m}$$

Hence, vol. of sludge produced per million litre of waste water.

= 3.415 cu. M

(b) unit wt of raw sludge

$$= \frac{\text{wt. of solids + wt. of water}}{\text{volume of sludge}}$$
$$= \frac{137.5 + 3300}{3.415} \text{kg/m}^3$$
$$= \frac{3437.5}{3.415} \text{kg/m}^3$$
$$= 1007 \text{ kg/m}^3$$

© 45% of raw sludge is changed into liquid and gas, means that 45% of solids are consumed (digested).

$\therefore$ wt. of dry solids left in the digested sludge

= (100 – 45) % of total solid
$$= \frac{55}{100} \times 137.5 \text{ kg}$$
= 75.625 kg

since digested sludge contains 90% m.c. we have The volume of digested sludge

$$= \left[\frac{\text{wt. of solids left in digested sludge}}{\text{unit weight of solids}}\right] + \left[\frac{\text{wt. of meter}}{\text{unit wt. water}}\right]$$

$$= \left[\frac{75.625}{1.2\times1000} + \frac{75.625\times\frac{90}{100}}{1000}\right] m^3$$

$$= 0.063 + 0.681$$

$$= 0.744 \text{ cu. m}$$

Hence, the volume of digested sludge per million litre of waster water = 0.744 cu.m

22. The sewage of a certain town contains 600 ppm of suspended matter. Assuming that 55% of this settled down in plain sedimentation tank, and the sludge collected has a water content of 95% calculate has a water content of 95% calculate its quantity per million litre, both in bulk and weight. Assume sp. Gravity 1.2

Solution:-

Suspended matter in sewage

= 600 ppm
= 600 mg / l

For 1 million litre of sewage, we have the suspended matter.

$$= \frac{600}{10^6}\times10^6 \text{ kg}$$

= 600 kg.

Now, 55% of this matter is settled as sludge, and therefore quantity of sludge solids.

= 0.55 × 600

= 330 kg.

The sludge is having 95% m.c. which, means 5 kg of dry solids will made 100 kg of wet sludge.

∴ 5 kg of dry solid make = 100 kg of sludge

∴ 330 kg of dry solids make

$$= \frac{100}{5}\times330$$

$$= 6600 \text{ kg of sludge}$$

Hence, the wt. of sludge formed per million litre of sewage = 6600 kg.

$$\text{Volume of sludge} = \frac{\text{wt. of sludge}}{\text{unit of wt. of sludge}}$$

$$= \frac{6600\,\text{kg}}{1020\,\text{kg/m}^3}$$

[∴ unit wt. of sludge

= sp. Gravity × unit wt. of water.
= 1.02 × 1000
= 1020 kg / m^3]

= 6.47 m^3

Hence, the vol. of sludge formed per million litre of sewage.

= 6.47 cu.m

23. Design a sludge digestion tank for 40,000 people. The sludge content per capita per day is 0.068 kg. The moisture of the sludge is 94% The sp. Gravity of the wet sludge is 1.02 and 3.5 percent of the digester vol. is daily filled with the fresh sludge, which is mixed with the digested sludge.

Solution:-

Dry sludge content produced by 40,000 persons

= 0.068 × 40, 000 kg
= 2, 720 kg / day

94% moisture content means that 6 kg of dry sludge will produce 100 kg of wet sludge.

∴ 6 kg of dry sludge produces wet sludge
= 100 kg

2720 kg of dry sludge produces wet sludge

$$= \frac{100}{6. \times 2720}$$
$$= 45333 \text{ kg}$$
$$= 45.3 \text{ t/day}$$

Volume of wet sludge produced

$$= \frac{\text{wt. of sludge}}{\text{unit. wt. of sludge}}$$
$$= \frac{45.3}{1.02} \text{m}^3/\text{day}$$

∵ Unit wt. of sludge in 6 / m^3

sp. gravity × unit wt. of water $\left(\text{i.e } 1\text{t} / \text{m}^3\right)$

$$= 1.02 \times 1$$
$$= 1.02 \text{ t/m}^3$$
$$= 44.4 \text{ m}^3/\text{day}$$

44.4 m^3 of fresh sludge is added to the tank daily, to fill 3.5% of the digester capacity.

$\frac{3.5}{100} \times$ capacity of digester

=volume of fresh sludge produced daily

$=44.4\ m^3$

$\therefore$ or capacity of digester required

$= \frac{44.4 \times 100}{3.5}$

$= 1268.9$ cu.m

Providing 30% additional capacity for fluctuations, we have,

The required digester capacity,

$= 1268.9 \times 1.3$

$= 1650$ cu. M (say)

Now, providing 6 m depth of the cylindrical digestion tank, we have

The cross sectional area of the tank

$= \frac{1650}{6}$

$= 275\ m^2$

$\therefore$ Dia of tank $= \sqrt{\frac{257}{\pi/4}}$

$= \sqrt{\frac{257}{0.785}}$

$=18.7$m.

Hence, provide a cylindrical sludge digestion tank, 6m deep and 18.7 in diameter, with an additional hoppered bottom of 1:1 slope foe collection of digested sludge.

24. A sewage containing 200mg/l of suspended solids is passed through primary setting tanks, tricking filters, and secondary settling tanks, how much gas will probably be produced in the digestion of sludge from on million litre of sewage?

Solution:

Total suspended solids in sewage =200mg/l

Assuming 90% removed of suspended solids in complete treatment, we have.

The suspended solids removed
=90% x 200 mg/l
=180mg/l.

Assuming volatile solids to be equal to 70% of suspended solids, we have
Volatile solids removed
=70%x180mg/l
=126mg/l

Now, assuming that the volatile solids (matter) is reduced by 65% in the sludge by digestion, we have

Volatile solids reduced

=65%x126mg/l
=81.9mg/l
∴ Volatile matter reduced per million litre of sewage produced per kg of volatile matter reduced, we have the gas produced per million litre of sewage

=0.9x81.9 cu.m.
=73.71 cu m.
=73710 litres.

25. A sewage containing 200 mg/l of suspended solids is passed through primary settling tank. The solids from the primary settling tank are digested to recover the gas. Find the likely volumes of mathene and carbon di oxide produced in the digestion of the sludge from 10,000 m^3 of sewage. Calculate the fuel value of the gas produced. State clearly the assumption made.

Solution:

Total suspended solids in sewage =200mg/l
Assuming that 60% of suspended solids are removed in the primary settling tank, we have the suspended solids removed as sludge.
=60%x200 mg/l
=120mg/l

Now assuming that the volatile solids present are 70% of the suspended solids, we have

∴ The volatile solids removed
=70%x120mg/l
=84mg/l
Further, assuming that the volatile matter is reduced by 65% in sludge digestion, we have
Volatile matter reduced =65%x84mg/l
=54.6mg/l.
Hence, volatile matter reduced in 10,000 cu m of sewage

$$= 54.6\frac{10{,}000x1000}{10^6}\text{kg.}$$

$$= 546\text{kg}$$

Now, assuming that 0.9 cu. M of gas is produced per kg of volatile matter reduced, we have
Total quantity of gas produced

=0.9x546 cu m.
=491.4 cu. M.

Assuming that the produced gas contains 65% of methoane and 30% of carbon di oxide, we have
Methane produced =0.645x491.4 cu m.
=319.41 cu. M.
carbondioxide produced = 0.30x491.4 cu m.
=147.42 cu m.

Now assuming that the methane in the sludge gas has a fuel value of 36,000 kg/m^3, we have
The fuel value = 36,000x391.41kj
= 11.50M.kj.
Now, assuming a boiler efficiency of 80% we have the amount of heat that can be furnished by the boiler.

=80%x11.50mkj
=9.2mkj
$=\frac{9.2}{4.18}mkc^2$
=2.2 million kilo calorie.

26. (a) calculate the area of land required for drying the sludge from the digestion tank for 40,000 population, designed in qn. No. 8.
(b) Also design the dimensions of beds.

Solutions:
(b)The volume of wet sludge from the sewage of 40,000 population was worked out as 44.4m^3/day
Let it be spread in 22.5 cm thick layer (ie between 20 to 30 cm thick layer) on under drained said beds, then
The area of beds required
$=\frac{44.40}{225}m^2$
$=197.3m^2/day.$
Under tropical Indian conditions, the beds get dried out in about to days and hence taking 2 weeks as average drying time including wet days of rainy season, we can utilize the same bed= $\frac{52*}{2}=26$ times in an year *.

$\therefore$ Area of bed required per year

$=\frac{197.3x365}{26}$
$=2770m^2(say)$
Making 100% allowance for space for storage, repairs, and resting of beds, etc, we have
The total area of beds required

=2x2770 m^2
=5540 m^2
=0.554 hectares Ans.
(b) Now, using 15x30 m sized beds, we have the No. of beds required

$=\frac{5540}{15x30}$
$=12.3$

So let us use 14 nos. of beds, with size as:
$Area=\frac{5540}{14}$
=395.7m^2

using 15m width,

$$\text{length} = \frac{395.7}{15}$$

$$= 26.4\text{m}.$$

Hence, use 14 beds, of size 15mx26.4m in plan. The beds should be provided with under drains and side walls, with typical section and plan as shown in figure.

27. Describe the mechanical methods of dewatering sludge?

Droed or dewatered by mechanical means, such as by vacuum filtration or by high speed centrifuges.

In vacuum filtration process, the sludge is first mixed with a consequent such as ferric chloride and then conveyed to a vacuum filter, consisting of a hollow rotating drum, covered with a replaceable filter cloth. The drum rotator partly submerging into the sludge. The vacuum created by a pump with in the drum draws the moisture from the sludge through the cloth. The sludge cake which is formed on the out side of the drum is removed by a scraper as we drum rotates.

High – speed centrifuges: are also used for drying of raw or digested sludges, and are becoming more popular because of small area requirements. There methods may remove about 50% moisture.

Vacuum filtration or centrifugation of raw sludge is often adopted in situation where sludge is to be disposed of by incineration (i.e. burning). These mechanical methods of drying are generally used when the available area is less than there required for sludge drying beds, or where the clomater are too cold or at places where rains are frequent as not to permit natural drying or as a preliminary to heat drying for making fertilizer.

28. Determine the liquid volume before and after digestion and percentage reduction for 600 kg (dry basis) of primary sludge having the following characteristics.

	Primary	**Digested**
Solids (%)	6	12
Volatile matter (%)	65	65
Specific gravity of fixed solids	2.5	2.5
Specific gravity of voluble solids	1.0	1.0

Solution:-

1) Computation of average spe. Gravity of all the solids in primary sludge

$$\frac{100}{S_S} = \frac{35}{2.5} + \frac{65}{1.0}$$

From which $S_S = 1.266$ (primary solids)

2) Computation of sp. Gravity of primary sludge

$$\frac{100}{S_{SC}} = \frac{6}{1.266} + \frac{94}{1}$$

$$S_{S1} = 1.013$$

3) Computation of volume of primary sludge

$$V_{S1} = \frac{w_s}{\rho_\omega S_{SC} P_S} = \frac{600}{1000 \times 1.013 \times 0.06}$$

$$= 9.874 \text{ m}^3$$

4) Computation of % volatile mater after digestion fixed matter in primary sludge = 0.35×600

= 210 kg

volatile matter in primary sludge = $0.65 \times 600 = 390$ kg

Volatile matter after digestion = 0.35×390 (65% of 360 kg has been digested on digestion).

$\therefore$ Total matter after digestion = $210 + 0.35 \times 390$

$$\therefore \text{ Volatile matter} = = \frac{0.35(390)}{210 + 0.35(390)} \times 100$$

$$= 39.39$$

5) Computation of average spe. Gravity of all the solids in digested sludge

$$\frac{100}{S_S} = \frac{60.61}{2.5} \neq \frac{39.39}{1}$$

$$= 1.571 \text{ (digested sludge)}$$

6) Computation of sp. Gravity of digested sludge

$$\frac{100}{S_{dsL}} = \frac{12}{1.571} + \frac{88}{1}$$

$$S_{dsL} = 1.046$$

7). Computation volume of digested sludge

$$V_{dsL} = \frac{w_{ds}}{\rho_\omega S_{dsL} . P_s}$$

$$w_{ds} = 200 + 0.35(390)$$

$$= 336.5 \text{ kg}$$

$$V_{dsL} = \frac{336.5}{1000 \times 1.046 \times 0.12} = 2.681 \text{ m}^3$$

8) Reduction of sludge volume after digestion

$$\% \text{ reduction } = \frac{9.874 - 2.681}{9.874} \times 100 = 72.85\%$$

29. Design a gravity thickens for thickening the combined primary and activated sludge from a treatment plant for 200,000 population.

Solution:-

Let us assume / capita settle able solids in primary sludge as 54gm / day and per capita settle able S_S in activated sludge as 31gm / day making a total S_S as 54 + 31 = 85 gm / day table 16.1

$\therefore$ lot of combined sludge = $85 \times 10^{-3} \times 200{,}000$

$= 17000 \text{ kg/d}$

Recommended average surface loading = 40 kg / m^2 / d

Hydraulic loading regd = 25 m^3 / m^2 /d

Let as assume sp. gravity of wet mixed sludge = 1.008 and solids in combined sludge as 3%.

The volume of wet sludge / d is given

$$V_{S1} = \frac{w_s}{\rho_\omega S_{S1} P_s}$$

$$= \frac{17000}{1000 \times 1.008 \times 0.03} = 562 m^3/d$$

Surface Area needed $\frac{17000}{40} = 425 m^2$

Flow needed from giving hydraulic loading of 25 m^3 / m^2 / d = 25 $\times$ 425 = 10625 m^3 / m^2 /d
Balance of 10625 – 562 = 10063 m^3 / d is made available by blending with primary or secondary effluent.

Let us provide a side water depth of 3m

$\therefore$ sludge detention period = V/Q

$$= \frac{425 \times 3}{562} \times 24$$

$= 54.5$ hrs

This is more than 24 hrs and hence o.k.

Let us provide a circular sludge blanket type thicken

$$\phi \text{ of tank} = \sqrt{\frac{425 \times 4}{\pi}} = 23.26 m$$

Let as provide a 24m dia. Tank

Sludge blanket restricted to 1m is adopted. Expected solids in the thickened sludge = 6%

30. Design a sludge drying bed for digested sludge from an activated sludge plant serving 200,000 people.

Solution:-

From cable 16.1, total solids remaining on digested sludge (combined primary $\times$ activated)

= 57 gm / cap / d

Daily solids = 200,000 $\times$ 57 $\times$ 10^{-3} = 11400 kg / d

Let us adopt a dry solids loading of 100kg 1m^2 / y

$\therefore$ Area of bed needed = $\frac{11400 \times 365}{100} = 41610\,m^2$

Check for per capita Area = $\frac{41610}{200000} = 0.208\,m^2$

(This is within the recommended range of 0.175 to 0.25)

Let us adopt 8m wide $\times$ 30m long beds with single pt discharge and a bed slope of 0.5%

$\therefore$ No. of beds = $\frac{41610}{8 \times 30} = 174$

Assuming 2 months of rainy season in a year and sweets for drying and one week for preparation and repair of bed, number of cycles / year = $\frac{(12-2)4}{4} = 10$

Let us Assume 7%. Solids and αsp. Gravity of 1.025, the volume of digested sludge is given by

$$V_{Sl} = \frac{w_s}{\rho_\omega . S_{sl} . P_s}$$

$$= \frac{11400}{1000 \times 1.025 \times 0.07} = 1.59\ m^3/d$$

$\therefore$ Depth of application of sludge = $\frac{159 \times 365}{174 \times 8 \times 30 \times 10}$

$= 0.139m$

$\approx$ 14 cm