12.0 TUTORIAL

1. Solids analyses were conducted on a soybean processing wastewater. 50 mL of wastewater is used for total solids analysis and 100 mL of wastewater is used for suspended solids analysis. The laboratory results are:

Weight of empty dish	54.222 g
Weight of dish + residue after evaporation at 105°C	54.475 g
Weight of dish + residue after ignition at 550°C	54.455 g
Weight of filter	0.2160 g
Weight of filter + residue after drying at 105°C	0.2215 g
Weight of filter + residue after ignition at 550°C	0.2180 g

Based on the test data above, determine the concentration of total solids, total volatile solids, total fixed solids, suspended solids, volatile suspended solids and fixed suspended solids in mg/L.

2. Solids analyses were conducted on the domestic wastewater that was tested for BOD. The tests were done in duplicate. Based on the following test data, calculate the concentrations of total solids, total volatile solids, suspended solids, and volatile suspended solids of the sample.

assignment

Dish no.	1	2
Weight of empty dish (g)	52.842	53.25
Weight of dish with sample (g)	110.0	104.0
Weight of dish with dry solids (g)	52.902	53.308
Weight of dish with ignited solids (g)	52.859	53.287
Weight of filter paper (g)	0.1160	0.1165
Weight of filter with dry solids (g)	0.1270	0.1353
Weight of filter with ignited solids (g)	0.1170	0.1208
Sample volume (mL)	48	72

3. A Total Solids and Suspended Solids test was carried out on water sample from Sg. Batu Tugoh. The relevant information is as follows:

Weight of filter and dish	=	0.0896 g
Weight of drying dish	=	53.625 g
Weight of filter and dish + residue	=	0.1032 g
Weight of dry solids in dish	=	53.649 g — DS
Volume of sample filtered	=	100 mL
Volume of sample dried	=	50 mL

Calculate:

(i) Total solids (mg/L)
(ii) Suspended solids (mg/L)
(iii) Dissolved solids (mg/L)

4. A standard five-day BOD test is run using a mix consisting of four parts distilled water and one part wastewater. The initial DO of the mix is 9.0 mg/L and the DO after five days is determined to be 2.5 mg/L. What is BOD_5?

$$BOD_5 = \frac{DO_i - DO_f}{P} = \frac{9 - 2.5}{1/5} = 6.5 \times 5 = 32.5 \text{ mg/L}$$

5. A BOD test is to be run on a sample of wastewater that has a five-day BOD of 210 mg/L. The initial DO of a mix of distilled water and wastewater is 7.9 mg/L. Roughly what maximum volume of wastewater should you put in the bottle if you want to have at least 2.0 mg/L of DO remaining at the end of the five days?

6. If the BOD_5 for some wastewater is 220 mg/L and the ultimate BOD is 310 mg/L, find the reaction rate constant k (base e) and K (base 10).

7. If the BOD of a municipal wastewater at the end of seven days is 70.0 mg/L and the ultimate BOD is 95.0 mg/L, what is the reaction rate constant (base 10)?

8. Some wastewater has a BOD_5 of 180 mg/L at 20°C. The reaction rate K at that temperature has been determined to be 0.12/day.
   (i) Find the ultimate BOD
   (ii) Find the reaction rate constant at 15°C
   (iii) Find BOD_5 at 15°C

9. A BOD analysis was performed on a municipal wastewater. The 300-mL test bottle was filled with 2.0% wastewater mixed with dilution water. The initial dissolved oxygen (DO) was 8.3 mg/L. The sample is then put in the incubator and set at 20°C. Since the fifth day falls on public holiday, the final DO does not get measured until the seventh day. The final DO is measured at 4.5 mg/L. Assuming k_{30} (base e) is 0.2 day^{-1}, determine the $_{20}BOD_5$ and $_{30}BOD_3$ of the sample.

10. The following data are obtained from a BOD test that was carried out at 20°C.

Time (day)	DO (mg/L)
0	7.8
1	7.1
2	6.5
3	6.1
4	5.6
5	5.2

If the BOD_5 is 52 mg/L, determine:

   (i) Dilution factor
   (ii) K_{20} using graphical method
   (iii) $_{30}BOD_3$

11. A COD test was carried out on a batik factory wastewater. The relevant information is as follows.

Volume of potassium dichromate standard solution 0.1N	=	10.0 mL
Volume of wastewater sample	=	20.0 mL
Wastewater sample dilution	=	10X
Fe^{2+} standard solution	=	0.1N
Volume of Fe^{2+} standard solution needed for wastewater sample	=	13.55 mL
Volume of Fe^{2+} standard solution needed for distilled water	=	34.70 mL

Calculate the COD value for the batik factory wastewater.

12. Calculate the peak flow (MLD) for a location having a 200 m^2 area of factories with 279 staffs, 1,500 residential houses, 300 mosque goers, a hospital with 240 beds, a primary school with 756 pupils, and an area of 1.5 km^2 for restaurants and recreational activities.

13. Wastewater is collected from a 50 hectare area that consists of 600 residential unit and 0.7 hectare of commercial centre. The wastewater generated is 200 liter per capita per day. Calculate the average flow and peak flow of wastewater into sanitary sewer.

14. A new sewage treatment plant will be constructed in the upland of Kg Sejahtera with area 60 m x 25 m. Data on existing building/infrastructure at Kg Sejahtera are provided below to help a design calculation.

BUILDING / INFRASTRUCTURE	UNIT / AREA
Residential house	500 units
Sek. Ren. Keb. Sejahtera (500 students)	1 unit (9000 m^2)
Pusat Kesihatan Sejahtera (20 beds)	1 unit (5000 m^2)
Manufacturing food factory (200 staffs)	1 unit (10000 m^2)
Restaurant (10 staffs)	1 unit (500 m^2)

(i) Based on information given, calculate average daily flow of sewage need to be treated

(ii) Assuming a using of water at 7.00 a.m is a peak hour, calculate the flow of sewage on that time.

15. A housing scheme is to be constructed and consists of the following premises:

2500 units of residential houses
Primary school for 1200 students
Mosque for 300 people
Commercial centre with floor area 7500 m^2

(i) Determine the total population equivalent (PE) for the housing scheme. Make logical assumptions in your calculation

(ii) Calculate the average flow of sewage generated
(iii) Determine the peak flow factor
(iv) Calculate the peak flow

16. A rectangular sedimentation tank is to be designed for a flow of 20 million litre per day using a 3:1 length/width ratio and overflow rate of 24 m^3/m^2. day. The tank is to be 2.5 m deep. Determine the dimension for the tank and the detention time.

17. A settling tank have to treat 50 MLD water. The depth of the tank is 3.5 m and the retention time is 2 hours. Find the diameter and overflow rate of the tank.

18. A treatment plant operates with two primary clarifiers, both 27.5 m in diameter and having 3 m side water depths. The effluent weirs are inboard, set on diameter of 25.6 m. The annual average flow is 22 400 m^3/d, and the peak flow is 78 000 m^3/day. Calculate the overflow rates, detention time and weir loading.

19. Two circular primary clarifiers are to be installed in a sewage treatment plant processing the wastewater for a town of 10 000 PE. Each clarifier has side water depth of 3.3 m. Design criteria for surface overflow rate has been set by local authority at a maximum of 40 m/d for average condition. The clarifier is designed to remove 35 percent BOD_5 and 65 percent SS. The wastewater contains 200 mg/L BOD_5 and 240 mg/L SS.

Based on the information given, determine :
(i) The dimension of the clarifier
(ii) HRT
(iii) Weir loading rate
(iv) BOD_5 and SS concentrations in the effluent of the clarifiers

20. A sewage treatment plant is designed to treat sewage from a population of 25,000 PE.

(i) Determine the peak flow rate (in m^3/d) generated by the population
(ii) Determine the minimum diameter required for a primary clarifier considering the minimum surface overflow rate of 45 $m^3/m^2/d$ at peak flow
(iii) Based on your answer in (ii), calculate the surface overflow rate ($m^3/m^2/d$) during average flow
(iv) If the BOD influent rate is 60 g/cap/d, and the primary clarifier efficiency is 65%, determine the BOD effluent from the clarifier in mg/L

21. Determine the biomass concentration of the activated sludge system based on the following information:

Flow rate	=	18 300 m^3/day
Influent BOD	=	160 mg/L
Effluent BOD	=	5 mg/L
Solids Retention Time	=	9 days
Y	=	0.55
k_d	=	0.04 per day
Volume of reactor	=	6100 m^3

22. An activated sludge system treats wastewater from an industry with a flow rate of 10 000 m^3/day. The BOD of the raw wastewater is 1200 mg/L and after treatment, the BOD is to be reduced to 50 mg/L. Pilot plant studies showed that this can be achieved with a Solids Retention Time (SRT) of 5 days and MLSS of 5000 mg/L. Y and k_d values are 0.7 and 0.03 per day respectively.

Calculate:
(i) Volume of reactor
(ii) Biomass wasted daily
(iii) F/M ratio.

23. An activated sludge treatment plant treats 10,000 m^3/day of sewage. The influent BOD is 175 mg/L and is required to reduce to 20 mg/L after treatment. Based on the following information:

Volumetric load	=	0.6 kgBOD/m^3.day
Y	=	0.5
k_d	=	0.05
MLSS	=	2500 mg/L

Calculate:
(i) Volume of reactor
(ii) Hydraulic Retention Time
(iii) Solids Retention Time
(iv) F/M ratio

24. An activated sludge system is designed to treat 30 MLD of sewage. Based on the following information:

F/M ratio	=	0.5 kg BOD_5/kg MLSS. day
BOD_5 influent	=	250 mg/L
Mean cell residence time	=	10 days
MLSS concentration	=	5 000 mg/L
Underflow concentration	=	10 000 mg/L
Y	=	0.5 kg/kg
k_d	=	0.05 per day

Calculate:

(i) Volume of the reactor
(ii) Hydraulic retention time
(iii) Mass of wasted sludge per day
(iv) Volumetric loading in unit kg BOD_5/m^3. day
(v) Sludge recycle ratio

25. An activated sludge system is designed to treat a domestic wastewater from a population of 50 000. The wastewater that enters into the aerated reactor with BOD_5 of 200 mg/L has to be reduced to 20 mg/L in order to comply with the Standard A.

A complete-mix reactor is to be used and from a pilot plant study, the Y and k_d values are 0.5 kg/kg and 0.05 per day respectively.

(i) If the food and micro organism ratio is given as 0.3 kg BOD_5 per kg MLSS per day and the biomass concentration in the aerated reactor has to be maintained at 2500 mg/L, calculate the volume of the aerated reactor.
(ii) Determine the mean cell-residence time.
(iii) From the answers obtained in part (i) and (ii) and also the information given above, compute the daily amount of biomass to be wasted.
(iv) Determine the recycle ratio of the system. Assuming an underflow concentration of 8,000 mg/L from the secondary clarifier.

26. An Extended Aeration treatment plant consists of an aeration compartment with a volume of 1320 m^3. The plant treats sewage from a population of 7500. If the BOD of the sewage is 250 mg/L and the MLSS is 4000 mg/L, calculate the F/M ratio and the volumetric loading.

27. An EA STP receives 2500 m^3 of sewage daily with a BOD concentration of 300 mg/L. The design F/M ratio is 0.075 kg BOD/kg MLSS.day. The MLSS concentration is 5000 mg/L and the SRT is designed for 30 days.

(i) Calculate the volume of reactor.
(ii) Determine the volumetric loading
(iii) Check the HRT
(iv) Calculate the amount of sludge wasted per day.

28. An EA STP treats sewage with a BOD of 250 mg/L, from a residential park with a population equivalent of 10 000. The STP has two aeration tanks and two clarifiers. Determine the size of the aeration tanks and the clarifiers. Assume appropriate values for F/M ratio and MLSS. Check the HRT and the volumetric loading for the aeration tanks.

Use the following criteria to design the clarifiers:
Surface overflow rate = 12.5 m^3/m^2.day at average flow
Depth of clarifier = 4.0 m
HRT = minimum of 2.0 hours at peak flow

29. A biotower with plastic media treats 17500 m^3/day of sewage with BOD concentration of 200 mg/L. The treatability constant of the sewage is 0.05 min^{-1} at 20°C. Using a recycle ratio of 2:1 and a tower of height 7.0 m, calculate the area required to produce an effluent of 20 mg/L at 33°C.

30. A trickling filter plant consists of a primary sedimentation tank, a trickling filter 21 m in diameter and 2 m depth, and a secondary sedimentation tank. The primary effluent BOD is 100 mg/L, the plant final effluent is 25 mg/L and the recirculation flow is 0.5 of the wastewater flow entering the plant. The temperature of the water is 15°C. The constants for the random plastic media are n = 0.5 and k_{20} = 0.055 min^{-1}. Calculate the hydraulic loading.

31. Wastewater from Taman Cenderawasih is treated through a bio tower. These are the data related to the bio tower:

Flow rate	=	20 000 m^3/day
Minimum temperature of the area	=	34°C
Medium height	=	2 m
Influent BOD	=	300 mg/L
Effluent BOD	=	20 mg/L
Recirculation flow rate to the tower	=	35 000 m^3/day
Wastewater treatability constant	=	0.09 min^{-1} at temperature 20°C
Medium coefficient	=	0.5

Compute:
(i) Ratio of recycled flow to the influent flow
(ii) Hydraulic loading (m^3/m^2.min)
(iii) Volume of the medium needed

32. Calculate the efficiency of a trickling filter at 30°C. The filter has the following criteria:

Height	= 1.8 m
Hydraulic load	= 5 m/day
Recycle ratio	= 2:1
Treatability constant	= 1.79 per day

Assign 33. A 3 m diameter biotower has been designed to treat sewage from 22,000 PE. The influent BOD of the treatment plant is 250 mg/L. The wastewater flow through a primary clarifier which remove 35% of the BOD and then flow into the biotower. The constants for the random plastic media, n is 0.44, the recycle ratio is 2, and the operating temperature is 25°C.

(i) Determine the reaction rate constant, K_{25} if the existing BOD effluent is 50 mg/L.

(ii) What would be the biotower's effluent at 20°C if the recycle ratio is increased to 4?

34. Design a waste stabilization pond to treat sewage from a residential area. Use the data below in your design:

Population Equivalent	=	20,000
Sewage generation rate	=	220 litres/person.day
Sewage BOD	=	330 mg/L
Design temperature	=	25°C
Effluent standards:	Effluent BOD	< 50 mg/L
	Effluent FC	< 5000 per 100 mL

35. Design a waste stabilization pond:

Population Equivalent	= 50000
Raw wastewater BOD_5	= 230 mg/L
Design temperature	= 28°C

(i) Determine the surface area required for the facultative pond with organic loading less than 380 kg/ha. day.

(ii) Estimate the HRT of the facultative pond if the pond depth is 1.5 m.

(iii) If the HRT of each maturation pond is 3 d and the depth is the same as the facultative pond, determine the required number of the maturation pond to produce an effluent no more than 1000 FC/100mL.

(iv) Determine the final effluent BOD.

36. Design a waste stabilisation pond to treat 8 000 m^3/d of wastewater with a BOD_5 removal efficiency of 90 percent under the following conditions:

Influent BOD_5	=	150 mg/L
Pond temperature	=	25°C
Retention time for maturation pond	=	3 days
Depth of facultative and maturation pond	=	1.5 m
Influent FC	=	$1x10^8$ FC/100mL
Effluent standards: FC	<	1 000/100 mL

37. A sewage treatment plant consisting of an aerated lagoon and a maturation pond is designed to operate under the following conditions:

Flow rate	=	2700 m^3/day
Influent BOD	=	250 mg/L
Surface area	=	4500 m^2
Depth	=	3.0 m
Temperature	=	27°C
Y	=	0.65
b	=	0.07
K at 20°C	=	5 per day
K_1 at 20°C	=	0.3 per day

(i) Calculate the HRT of the aerated lagoon
(ii) Determine the lagoon effluent BOD
(iii) If both the aerated lagoon and the maturation pond have the same size, calculate the BOD of the effluent from the maturation pond. (Assume 70% of the solids settled in the maturation pond)

38. A sewage treatment plant has two aerated lagoons arranged in series. Both lagoons have the same dimensions and are designed to operate under the following conditions:

Flow rate	=	2 150 m^3/day
Influent BOD	=	230 mg/L
Length of each lagoon	=	60 m
Width of each lagoon	=	45 m
Depth of wastewater	=	3.2 m
Temperature	=	25°C
Y	=	0.65
b	=	0.07/day
K at 20°C	=	5/day

(i) Determine the effluent BOD.

39. An aerated lagoon is designed to treat domestic wastewater from 40,000 PE. It comprised of an aerated lagoon followed by a maturation pond. Two systems are to be installed in parallel. The followings design consideration will be used:

BOD influent = 250 mg/L
Dissolved BOD effluent from aerated lagoon = 20 mg/L
Minimum operating temperature = 20°C
Maximum operating temperature = 35°C
Y = 0.65
b = 0.07 d^{-1}; K = 5 d^{-1} ; K_l = 0.3 (All values at 20°C)
Assume pond depth of 2.5 m

Answer the followings:

(i) HRT and oxygen requirement of each aerated lagoon
(ii) Area required for each aerated lagoon
(iii) Total BOD effluent of each lagoon
(iv) Effluent from maturation pond assuming 75% solid removal in the pond