
UNIVERSITI SAINS MALAYSIA

First Semester Examination
2010/2011 Academic Session

November 2010

EAP 313/2 – Wastewater Engineering
[*Kejuruteraan Air Sisa*]

Duration : 2 hours
[*Masa : 2 jam*]

Please check that this examination paper consists of **SIXTEEN (16)** printed pages including appendices before you begin the examination.

[*Sila pastikan kertas peperiksaan ini mengandungi **ENAM BELAS (16)** muka surat bercetak termasuk lampiran sebelum anda memulakan peperiksaan ini.*]

Instructions:

This paper contains **FOUR (4)** questions. Answer **QUESTION 1** and **ANY OTHER 2 QUESTIONS**.

Arahan:

*Kertas ini mengandungi **EMPAT (4)** soalan. Jawab **SOALAN 1** dan **MANA-MANA 2 SOALAN LAIN**.*

All questions **CAN BE** answered in English or Bahasa Malaysia or combination of both languages.

Semua soalan boleh dijawab dalam Bahasa Inggeris atau Bahasa Malaysia ataupun kombinasi kedua-dua bahasa.

All question **MUST BE** answered on a new sheet.

*Semua jawapan **MESTILAH** dijawab pada muka surat yang baru.*

Write the answered question numbers on the cover sheet of the answer script.

Tuliskan nombor soalan yang dijawab di luar kulit buku jawapan anda.

PART A: Compulsory

1. a) Sketch a process flow diagram for a conventional activated sludge treatment plant in Malaysia.
[5 marks]

- b) (i) Briefly explain, the significance of BOD in wastewater treatment and the reason why the BOD value is never equal to the ThOD or COD values.
[4 marks]

- (ii) As an environmental engineers, briefly explain the role of microorganisms in biological treatment processes.
[4 marks]

- c) A wastewater treatment plant is to be constructed to cater for a new housing scheme in Taman Megah. Calculate the number of houses in this Taman if the calculated average flow is 2,250 m³/day.
[4 marks]

- d) A wastewater treatment plant dischargers effluents with 250 mg/L of BOD for land treatment purpose. The slow-rate land treatment area is 2 ha/day and the daily effluent flow rate is 1000 m³/day. The land treatment effluent application cycle time is 7 days between two applications. Find the cycle average BOD loading rate.
[4 marks]

- e) Briefly describe the sources of wastewater. List raw sewage characteristics based on range and typical concentration.
[6 marks]

- f) A sedimentation tank is designed for Q peak and received wastewater from a population equivalent of 10,000 people. The dimension of the tank are given as follows:

Width 5m

Length 20 m

Depth 3 m

Calculate the

- i) Approaching velocity.

[4 marks]

- ii) Weir loading rate.

[4 marks]

- g) A wastewater treatment plant is to be designed based on the following data:

Population equivalent = 100,000

BOD = 250 mg/L.

Calculate the volumetric organic loading of a cylindrical trickling filter with a diameter of 5 m and height 10 m.

[5 marks]

PART B: Answer 2 out of 3 questions

2. a) Briefly, explain the principle of a grit chamber.

[6 marks]

- b) A sewer is to be designed for a population as follows.

Houses 5,000 unit

Day school 1,000 student

Wet market 100 unit

Dry market 50 unit

Calculate the population equivalent and the average flow.

[9 marks]

..4/-

- c) The wastewater in (b) is channelled into a rectangular grit chamber with the following data.

Volume of chamber 1,000 m³
Surface loading rate 40 m³/m².day
Length: Width ratio 4:1

Calculate the approaching velocity of this chamber.

[9 marks]

- d) State the affinity laws and illustrate pump performance curve. Explain the calculation process for pump performance in wastewater pumping.

[6 marks]

3. a) Briefly explain, the principle of an activated sludge system for wastewater treatment.

[6 marks]

- b) An extended aeration wastewater treatment plant is to be designed based on the following data:

Volume = 2,500 m³
Organic load = 1,500 kg/day
MLSS = 2,500 mg/L.

Calculate the food to microorganism (F:M) ratio.

[6 marks]

- c) Calculate the quantity of oxygen required for a given aeration tank based on the following design data:

Organic load = 250 kg/day

MLSS = 3,000 mg/L

$y = 0.6 \text{ mg/mg}$

$k_d = 0.05 \text{ day}^{-1}$

$\theta_c = 9 \text{ days}$

Remaining biodegradable BOD on day 5 is 35%

[8 marks]

- d) Distinguish the similarity and dissimilarity between aerobic bacteria and anaerobic bacteria during the breakdown of organic wastewater.

[5 marks]

- e) The BOD_5 (20°C) value of a given domestic wastewater is 432 mg/L. Assume reaction constant, $k = 0.21 \text{ day}^{-1}$ and temperature coefficient, $\theta = 1.053$,

- (i) Calculate the ultimate BOD and the 11-day BOD.

[2 marks]

- (ii) Calculate the BOD_5 value, if the bottle had been incubated at 37°C.

[3 marks]

4. a) Flow from a primary clarifier is 20000 m³/day with BOD 150 mg/L. If the organic load is 0.05 kg/m².day, determine the required diameter of the disc for RBC system to treat the wastewater.

[5 marks]

- b) A wastewater treatment plant has a flow rate equivalent of 5,000 people. If the MLSS of the aeration basin is 2,500 mg/L and the recycled flow rate from the sedimentation tank is 225 m³/day, calculate the required concentration of sludge to be recycled to the aeration basin to maintain the MLSS concentration of this basin.
[5 marks]
- c) Calculate the SVI of mixed liquor suspended solid (MLSS) concentration of 3,150 mg/L that settles to a volume of 160 mL in a 1-L cylinder within 30 minutes. Comment on your answer.
[5 marks]
- d) Describe and illustrate wastewater treatment techniques including operational processes.
[5 marks]
- e) Calculate net wastewater generation from the following data:
Total Population = 1000
Water consumption rate = 200 L/cap.day
Infiltration rate = 15%
Evaporation rate = 5% .
Express the net wastewater generation in m³/day and L/sec.
[5 marks]
- f) A pump which is direct driven by an electric motor, lifts 93600 litres of wastewater per hour against a total head of 21 meters. Compute the hydraulic horse power (*Hp*) of the pump. If the pump has an efficiency of 72 percent, calculate the size of the prime mover required to operate the pump.
[5 marks]

BAHAGIAN A: Soalan wajib

1. a) *Lakarkan carta alir loji olahan enap cemar teraktif lanjutan di Malaysia..*
[5 markah]
- b) i) *Terangkan secara ringkas kepentingan BOD dalam olahan air sisa dan mengapa nilai BOD tidak akan pernah sama dengan ThOD atau nilai COD*
[4 markah]
- ii) *Sebagai jurutera alam sekitar, terangkan secara ringkas peranan mikroorganisma dalam proses olahan biologi.*
[4 markah]
- c) *Sebuah loji olahan air sisa akan dibina untuk suatu taman perumahan baru di Taman Megah. Kirakan bilangan rumah di taman ini sekiranya kadar alir purata yang terhasil adalah $2,250 \text{ m}^3/\text{hari}$.*
[4 markah]
- d) *Suatu loji olahan air sisa melepaskan efluen akhir untuk tujuan olahan tanah dengan nilai BOD 250 mg/L . Kadar perlahan kawasan olahan tanah adalah 2 ha/hari dan kadar alir efluen harian adalah $1000 \text{ m}^3/\text{hari}$. Kitaran masa aplikasi efluen olahan tanah adalah 7 hari diantara dua aplikasi. Tentukan kadar bebanan COD purata kitaran.*
[4 markah]
- e) *Terangkan secara ringkas sumber air sisa? Terangkan ciri-ciri kumbahan dengan julat dan kepekatan tipikal.*
[6 markah]

- f) Sebuah tangki enapan yang direka bentuk pada kadar alir puncak, menerima air sisa dari Penduduk Setara 10,000 orang. Dimensi tangki adalah seperti berikut:

Lebar 5m

Panjang 20 m

Kedalaman 3 m

Kirakan:

- i) Halaju tuju.

[5 markah]

- ii) Kadar Empang Limpah.

[4 markah]

- g) Sebuah loji olahan air sisa perlu di reka bentuk berdasarkan data di bawah:

Penduduk Setara = 100,000

BOD = 250 mg/L

Kirakan Beban Organik Isipadu suatu turas cucur selinder dengan diameter 5m dan ketinggian 10 m.

[5 markah]

BAHAGIAN B: Jawab 2 dari 3 soalan

2. a) Terangkan prinsip kebuk kersik secara ringkas.

[6 markah]

- b) Suatu pembentung perlu direka bentuk untuk penduduk seperti berikut:

Rumah 5,000 unit

Sekolah harian 1,000 murid

Pasar basah 100 unit

Pasar kering 50 unit

Kirakan Penduduk Setara dan kadar alir purata.

[9 markah]

- c) *Air sisa dalam (b) dialirkan ke kebuk kersik segiempat dengan data berikut:*

<i>Isipadu kebuk</i>	<i>1,000 m³</i>
<i>Kadar Limpah Permukaan</i>	<i>40 m³/m².hari</i>
<i>Nisbah Panjang:Lebar</i>	<i>4:1</i>

Kirakan halaju tuju kebuk ini.

[9 markah]

- d) *Berikan undang-undang afiniti dan lakarkan lengkung prestasi pam. Terangkan proses kiraan prestasi pam dalam pengepaman air sisa*

[6 markah]

3. a) *Secara ringkas, terangkan prinsip sistem enap cemar teraktif dalam mengolah air sisa.*

[6 markah]

- b) *Suatu loji enap cemar pengudaraan lanjutan perlu direka bentuk berdasarkan data berikut:*

$$\text{Isipadu} = 2,500 \text{ m}^3$$

$$\text{Beban Organik} = 1,500 \text{ m}^3/\text{hari}$$

$$\text{MLSS} = 2,500 \text{ mg/L}$$

Kirakan nisbah Makanan ke Mikroorganisma (F:M).

[6 markah]

- c) Kirakan kuantiti oksigen yang diperlukan untuk sebuah tangki pengudaraan dengan data reka bentuk berikut:

Beban Organik = 250 kg/hari

MLSS = 3,000 mg/L

$y = 0.6 \text{ mg/mg}$

$kd = 0.05 \text{ hari}^{-1}$

$\theta_c = 9 \text{ days}$

Baki BOD boleh terurai pada hari ke 5 adalah 35%

[8 markah]

- d) Terangkan persamaan dan perbezaan antara bakteria aerobik dan bakteria anaerobik semasa penguraian air sisa organik

[5 markah]

- e) Nilai BOD_5 (20°C) suatu air sisa domestik adalah 432 mg/L. Anggap pemalar tindak balas, $k = 0.21 \text{ hari}^{-1}$ dan pekali suhu, $\theta = 1.053$

(i) Kirakan nilai BOD mauktamad dan nilai BOD hari ke-11.

[2 markah]

(ii) Kirakan nilai BOD, jika botol telah melalui pengeraman pada suhu 37°C .

[3 markah]

4. a) Kadar alir dari tangki enap primer adalah $20000 \text{ m}^3/\text{hari}$ dengan nilai BOD 150 mg/L. Jika beban organik adalah $0.05 \text{ kg/m}^2 \cdot \text{hari}$, tentukan keluasan cakera RBC yang diperlukan untuk mengolah air sisa ini.

[5 markah]

b) Suatu loji olahan air sisa mempunyai kadar alir yang setara dengan 5,000 orang penduduk. Jika MLSS di tangki pengudaraan adalah 2,500 mg/L dan kadar pusing balik dari tangki enapan adalah 225 m³/day, kirakan kepekatan enap cemar yang perlu dipusing balik ke tangki pengudaraan untuk mengekalkan kepekatan MLSS di tangki pengudaraan ini.

[5 markah]

c) Kirakan nilai SVI untuk kepekatan likur tercampur pepejal terampai (MLSS) berkepekatan 3,150 mg/L yang dalam 30 minit, mengena ke isipadu 160 mL dalam selinder 1 L. Komen jawapan anda.

[5 markah]

d) Terangkan dan lakarkan teknologi-teknologi olahan air sisa termasuk proses-proses operasinya.

[5 markah]

e) Kirakan penghasilan air sisa bersih dari data berikut:

Jumlah penduduk = 1000 orang

Kadar penggunaan air = 200 L/kapita. Hari

Kadar penyusupan = 15%

Kadar sejatan = 5%

Berikan jawapan dalam unit m³/hari dan L/saat.

[5 markah]

f) Suatu pam yang digerakkan oleh motor elektrik, mengangkat 93600 liter air sisa sejam dengan turus 21 m. Kirakan nilai kuasa kuda hidraulik (Hp) pam ini. Sekiranya kecekapan pam adalah 72% kirakan saiz penggerak primer yang sesuai untuk menggerakkan pam ini.

[5 markah]

APPENDICES
LAMPIRAN

Peak Factor = $4.7 p^{-0.11}$ (p in thousand)
 Faktor Puncak = $4.7 p^{-0.11}$ (p dalam ribu)

Retention time=Volume/discharge
 Masa tahanan = Isipadu /kadaralir

Population Equivalent = $\frac{\text{Organic load from premises}}{\text{Organic load from 1 person}}$
 Penduduk Setara = $\frac{\text{Beban Organik Premis}}{\text{Beban Organik 1 orang}}$

Manning: $Q=(1/n) (A) (R)^{2/3} (s)^{1/2}$

$V=(1/n) (R)^{2/3} (s)^{1/2}$

$R=A/P$

Width of screen = $\frac{(\text{width of blade} + \text{opening})}{\text{opening}} \frac{(\text{Discharge})}{(\text{velocity}) (\text{depth of wastewater})}$
 Lebar saring = $\frac{(\text{Lebar bilah} + \text{saiz bukaan})}{\text{Saiz bukaan}} \frac{(\text{Kadaralir})}{(\text{Halaju}) (\text{Kedalaman air sisa})}$

Pumping cycle = $\frac{\text{Actual volume}}{\text{Dry Weather Flow}} + \frac{\text{Actual volume}}{(\text{Pumping rate}-\text{Dry Weather Flow})}$
 Sela pengepaman = $\frac{\text{Isipadu sebenar}}{\text{Kadaralir Cuaca Kering}} + \frac{\text{Isipadu sebenar}}{(\text{Kadar pam}-\text{Kadaralir Cuaca Kering})}$

Surface Overflow Rate = $\frac{\text{Discharge}}{\text{Surface Area}}$
 Kadar Beban Permukaan = $\frac{\text{Kadaralir}}{\text{Luas Permukaan}}$

Solids Loading Rate = $\frac{(\text{Discharge}) (\text{Mixed Liquor})}{\text{Surface Area}}$
 Kadar Beban Pepejal = $\frac{(\text{Kadaralir}) (\text{Likur Tercampur})}{\text{Luas Permukaan}}$

Weir Loading Rate = $\frac{\text{Discharge}}{\text{Length of weir}}$
 Kadar Beban Empang Limpah = $\frac{\text{Kadaralir}}{\text{Panjang Empang Limpah}}$

Volume of pyramid = $(1/3) (\text{base area}) (\text{height})$
 Isipadu Piramid = $(1/3) (\text{luas dasar}) (\text{tinggi})$

$$\begin{aligned} \text{Organic Load} &= (\text{Discharge}) (\text{BOD}) \\ \text{Beban Organik} &= (\text{Kadaralir}) (\text{BOD}) \end{aligned}$$

$$\text{Primary Sedimentation Tank Area} = \frac{(\text{Flowrate} + \text{Return Flowrate}) (\text{Mixed Liquor})}{\text{Flux}}$$

$$\text{Keluasan Tangki Enap Primer} = \frac{(\text{Kadaralir} + \text{Kadaralir Pusing Balik}) (\text{Likur Tercampur})}{\text{Fluks}}$$

$$\text{Solids Flux} = \frac{\text{Settling velocity}}{(1/\text{Solid concentration}) - (1/\text{Settled Solids Concentration})}$$

$$\text{Fluks Pepejal} = \frac{\text{Halaju enapan}}{(1/\text{Kepekatan Pepejal}) - (1/\text{Kepekatan Pepejal Terenap})}$$

$$\text{BOD Kinetics} \quad \text{BOD}_t = L_o (1 - e^{-Kt})$$

Kinetik BOD

$$K_T = K_{20} (\theta)^{T-20}$$

$$L_T = L_{20} [1 + 0.02(T-20)]$$

$$\text{Thomas:} \quad (t/\text{BOD})^{1/3} = (kL_o)^{-1/3} + (k^{2/3}/6L_o^{1/3}) t$$

$$\begin{aligned} \text{Organic Load} &= (\text{Discharge}) (\text{BOD}) \\ \text{Beban Organik} &= (\text{Kadaralir}) (\text{BOD}) \end{aligned}$$

$$\text{Volumetric Organic Load} = \frac{(\text{Discharge}) (\text{BOD})}{\text{Volume}}$$

$$\text{Beban Organik Isipadu} = \frac{(\text{Kadaralir}) (\text{BOD})}{\text{Isipadu}}$$

$$\text{Food : Microorganism} = \frac{(\text{Discharge}) (\text{BOD})}{(\text{Volume}) (\text{Mixed Liquor})}$$

$$\text{Makanan: Microorganism} = \frac{(\text{Kadaralir}) (\text{BOD})}{(\text{Isipadu}) (\text{Likur Tercampur})}$$

$$\text{Aerial Organic Loading} = \frac{(\text{Discharge}) (\text{BOD})}{\text{Surface Area}}$$

$$\text{Beban Organik Kawasan} = \frac{(\text{Kadaralir}) (\text{BOD})}{\text{Luas Permukaan}}$$

$$\text{Oxygen Requirement} = \frac{Q \times \text{BOD}_5}{\text{BOD}_5/\text{BOD}_L} - 1.42 Px$$

Keperluan Oksigen

$$\text{Increased in Mixed Liquor} = \frac{y}{1+kd\theta c} (\text{Discharge})(\text{BOD})$$

$$\text{Pertambahan Likur Tercampur} = \frac{y}{1+kd\theta c} (\text{Kadaralir})(\text{BOD})$$

Return Sludge Ratio $R = \frac{\text{Return Sludge}}{\text{Discharge}}$

Nisbah enap cemar kembali $R = \frac{\text{Kadar alir kembali}}{\text{Kadar alir}}$

$$X_a = X_R(1/1+R)$$

Oxygen Requirement = $aL_r + bS_a$

a = BOD removal coefficient

L_r = BOD removed

b = sludge endogenous coefficient

S_a = Mass of Mixed Liquor

Keperluan Oksigen = $aL_r + bS_a$

a = *Pekali penyingkiran BOD*

L_r = *BOD tersingkir*

b = *pekali endogenous enap cemar*

S_a = *Jisim Likur Tercampur*

Oxygen Supply Rate = $\frac{\text{Oxygen Required}}{\text{BOD removed}}$

Kadar Bekalan Oksigen = $\frac{\text{Oksigen Diperlu}}{\text{BOD tersingkir}}$

Sludge Age = $\frac{\text{(Volume) (Mixed Liquor)}}{\text{(Wastage) (Return Mixed Liquor) + (Effluent Flowrate) (Effluent Solid)}}$
Umur = $\frac{\text{(Isipadu) (Likur Tercampur)}}{\text{(Kadar alir Disingkir)(Likur Tercampur Pusing Balik) + (Kadar alir Efluen)(Pepejal Terampai Efluen)}}$

$$1/\theta = yu - k_d$$

$$\theta_c = \frac{V \cdot \text{MLSS}}{Q_w \cdot \text{SS}}$$

Sludge Volume Index (SVI) = (Settled MLSS volume in 30 minutes) / MLSS
Indeks Isipadu Enap cemar (SVI) = *(Isipadu MLSS mengenalap dalam 30 minit)/MLSS*

Septic Tank, C = 225P
Tangki Septik, C = 225P

Pond design:
Rekabentuk kolam:

$$L_e/L_i = 1/(1+k_1t)$$

$$A = Q/Dk_1 [L_i/L_e - 1]$$

$$k_T = 0.30 (1.085)^{T-20}$$

Organic Loading = $L_i Q/A$
Beban Organik = $L_i Q/A$

Maximum Organic Loading = $7.5 (1.054)^T$
Beban Organik Maksimum = $7.5 (1.054)^T$

Population Equivalent Table

(Adapted from MS 1228 : 1991 : MALAYSIAN STANDARD: Code of Practice for Design and Installation of Sewerage Systems) dan Guidelines for Developers, Section 1 and 2, 1995

No	Types of Premises/ Establishment	Penduduk Setara (dicadangkan)
1	Residential	5 per house*
2	Commercial: Includes offices, shopping complex, entertainment/recreational centres, restaurants, cafeteria, theaters	3 per 100 m ² gross area
3	Schools/ Educational Institutions : - Day schools/ Institutions - Fully residential - Partially residential	0.2 per student 1 per student 0.2 per non-residential student 1 per residential student
4	Hospitals	4 per bed
5	Hotels with dining and laundry facilities	4 per room
6	Factories, excluding process water	0.3 per staff
7	Market (wet type)	3 per stall
8	Market (dry type)	1 per stall
9	Petrol kiosk/ Service stations	15 per toilet
10	Bus terminal	4 per bus bay
11	Taxi terminal	4 per taxi bay
12	Mosque	0.2 per person
13	Church/ Temple	0.2 per person
14	Stadium	0.2 per person
15	Swimming pool/ Sports complex	0.5 per person
16	Public toilet	15 per toilet
17	Airport	0.2 per passenger bay 0.3 per employee
18	Laundry	10 per machine
19	Prison	1 per person
20	Golf Course	20 per hole

* Water consumption rate equals to 225 liter/capita/day

Jadual Penduduk Setara

(Dipetik dari MS 1228 : 1991 : MALAYSIAN STANDARD: Code of Practice for Design and Installation of Sewerage Systems) dan Guidelines for Developers, Seksyen 1 dan 2, 1995

No	Jenis Premis	Penduduk Setara (dicadangkan)
1	Kediaman	5 per unit*
2	Komersial (termasuk pusat hiburan/rekreasi, kafeteria, teater)	3 per 100 m ² kawasan kasar
3	Sekolah/Institusi Pengajian : - Sekolah/institusi siang - Dengan asrama penuh - Dengan sebahagian asrama	0.2 per pelajar 1 per pelajar 0.2 per pelajar untuk pelajar tanpa asrama 1 per pelajar untuk penduduk asrama
4	Hospital	4 per katil
5	Hotel (dengan kemudahan masakan dan cucian pakaian)	4 per bilik
6	Kilang (tidak termasuk sisa yang diproses)	0.3 per pekerja
7	Pasar (jenis basah)	3 per gerai
8	Pasar (jenis kering)	1 per gerai
9	Stesyen petrol/Perkhidmatan	15 per tandas
10	Stesyen bas	4 per petak bas
11	Stesyen teksi	4 per petak teksi
12	Mesjid	0.2 per orang
13	Gereja/Kuil	0.2 per orang
14	Stadium	0.2 per orang
15	Kolam renang/Kompleks sukan	0.5 per orang
16	Tandas awam	15 per tandas
17	Lapangan terbang	0.2 per petak penumpang 0.3 per pekerja
18	Laundri	10 per mesin
19	Penjara	1 per orang
20	Padang golf	20 per lubang

* 1 kadar alir adalah setara dengan 225 liter/kapita/hari

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