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 m^3/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 m^3/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 dimensión 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]

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

Volume of chamber 1,000 m^3
Surface loading rate 40 m^3/m^2.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 m^3
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 mg/mg
kd = 0.05 day^{-1}
θc = 9 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 day^{-1} and temperature coefficient, θ = 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 m^3/day with BOD 150 mg/L. If the organic load is 0.05 kg/m^2.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 m^3/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 m^3/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 kadaralir purata yang terhasil adalah 2,250 m^3/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 kadaralir efluen harian adalah 1000 m^3/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 kadaralir 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 Penduk Setara dan kadaralir purata.

[9 markah]

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

Isipadu kebuk	*1,000 m^3*
Kadar Limpah Permukaan	*40 m^3/m^2.hari*
Nisbah Panjang:Lebar	*4:1*

Kirakan halaju tuju kebuk ini.

[9 markah]

d) *Berikan undang-undang afiniti dan lakarkan lengkung prestasi pam. Terangakan 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:*
Isipadu= 2,500 m^3
Beban Organik = 1,500 m^3/hari
MLSS = 2,500 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 mg/mg
kd = 0.05 hari^{-1}
θc = 9 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℃) suatu air sisa domestik adalah 432 mg/L. Anggap pemalar tindak balas, k =0.21 hari^{-1} dan pekali suhu, θ = 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^{o}C.*

[3 markah]

4. a) *Kadaralir dari tangki enap primer adalah 20000 m^3/hari dengan nilai BOD 150 mg/L. Jika beban organik adalah 0.05 kg/m^2.hari, tentukan keluasan cakera RBC yang diperlukan untuk mengolah air sisa ini.*

[5 markah]

b) *Suatu loji olahan air sisa mempunyai kadaralir 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 m^3/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, mengenap 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 m^3/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 = $\frac{\text{(width of blade + opening)}}{\text{opening}}$ $\frac{\text{(Discharge)}}{\text{(velocity) (depth of wastewater)}}$
Lebar saring = $\frac{\text{(Lebar bilah + saiz bukaan)}}{\text{Saiz bukaan}}$ $\frac{\text{(Kadaralir)}}{\text{(Halaju) (Kedalaman air sisa)}}$

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

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

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

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) (base area) (height)
Isipadu Piramid = (1/3) (luas dasar) (tinggi)

Organic Load = (Discharge) (BOD)
Beban Organik = (Kadaralir) (BOD)

Primary Sedimentation Tank Area = $\frac{\text{(Flowrate + Return Flowrate) (Mixed Liquor)}}{\text{Flux}}$
Keluasan Tangki Enap Primer = $\frac{\text{(Kadaralir + Kadaralir Pusing Balik)(Likur Tercampur)}}{\text{Fluks}}$

Solids Flux = $\frac{\text{Settling velocity}}{\text{(1/Solid concentration) – (1/ Settled Solids Concentration)}}$
Fluks Pepejal = $\frac{\text{Halaju enapan}}{\text{(1/Kepekatan Pepejal) - (1/Kepekatan Pepejal Terenap)}}$

BOD Kinetics $BOD_t = L_o (1- e^{-Kt})$
Kinetik BOD

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

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

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

Organic Load = (Discharge) (BOD)
Beban Organik = (Kadaralir) (BOD)

Volumetric Organic Load = $\frac{\text{(Discharge) (BOD)}}{\text{Volume}}$
Beban Organik Isipadu = $\frac{\text{(Kadaralir) (BOD)}}{\text{Isipadu}}$

Food : Microorganism = $\frac{\text{(Discharge) (BOD)}}{\text{(Volume) (Mixed Liquor)}}$
Makanan: Microorganism = $\frac{\text{(Kadaralir) (BOD)}}{\text{(Isipadu) (Likur Tercampur)}}$

Aerial Organic Loading = $\frac{\text{(Discharge) (BOD)}}{\text{Surface Area}}$
Beban Organik Kawasan = $\frac{\text{(Kadaralir) (BOD)}}{\text{Luas Permukaan}}$

Oxygen Requirement = $\frac{Q \times BOD_5}{BOD_5/BOD_L}$ - 1.42 Px
Keperluan Oksigen

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

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

Nisbah enap cemar kembali $R = \frac{\textit{Kadaralir kembali}}{\textit{Kadaralir}}$

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

Oxygen Requirement = aLr + bSa

a = BOD removal coefficient
Lr = BOD removed
b = sludge endogenous coefficient
Sa = Mass of Mixed Liquor

Keperluan Oksigen = *aLr + bSa*

a = *Pekali penyingkiran BOD*
Lr = *BOD tersingkir*
b = *pekali endagenous enap cemar*
Sa = *Jisim Likur Tercampur*

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

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

Sludge Age = $\frac{\text{(Volume) (Mixed Liquor)}}{\text{(Wastage) (Return Mixed Liquor) + (Effluent Flowrate) (Effluent Solid)}}$

Umur E.C. = $\frac{\textit{(Isipadu) (Likur Tercampur)}}{\textit{(Kadaralir Disingkir)(Likur Tercampur Pusing Balik) + (Kadaralir Efluen)(Pepejal Terampai Efluen)}}$

$1/\theta = yu - k_d$

$\theta_c = \frac{V.MLSS}{Q_w.SS}$

Sludge Volume Index (SVI) = (Settled MLSS volume in 30 minutes) / MLSS
Indeks Isipadu Enap cemar (SVI) = *(Isipadu MLSS mengenap 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_iQ/A
Beban Organik = L_iQ/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 Instituitions : - Day schools/ Instituitions - 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/InstitusiPengajian : - 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 kadaralir adalah setara dengan 225 liter/kapita/hari

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