UNIVERSITI SAINS MALAYSIA

First Semester Examination
2011/2012 Academic Session

January 2012

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

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

Please check that this examination paper consists of **FOURTEEN (14)** pages of printed material including appendices before you begin the examination.
[*Sila pastikan bahawa kertas peperiksaan ini mengandungi **EMPAT BELAS (14)** muka surat yang bercetak termasuk lampiran sebelum anda memulakan peperiksaan ini.*]

Instructions : This paper contains **FOUR (4)** questions. Answer **QUESTIONS 1** and **ANY OTHER 2 QUESTIONS.**
***[Arahan** : Kertas ini mengandungi **EMPAT (4)** soalan. Jawab **SOALAN 1** dan **MANA-MANA 2 SOALAN LAIN**.]*

All question **CAN BE** answered in English or Bahasa Malaysia or combination of both languages.
[Semua soalan boleh dijawab dalam Bahasa Inggeris ataupun kombinasi kedua-dua bahasa.]

All questions **MUST BE** answered on a new page.
[*Semua soalan **MESTILAH** dijawab pada muka surat baru*].

In the event of any discrepancies, the English version shall be used.
[*Sekiranya terdapat percanggahan pada soalan peperiksaan, versi Bahasa Inggeris hendaklah diguna pakai*].

PART A: Compulsary

1. (a) Sewage treatment plant (STP) is essential in this modern society. Based on your understanding describe about a standard STP with necessary sketches.

[6 marks]

(b) Define the following terms used in wastewater engineering:

(i) Organic matter

(ii) Organic load

[5 marks]

(c) Calculate the value of Biochemical Oxygen Demand (BOD) in mg/L from a small locality with a population of 1000 people and a wastewater flow rate of 225 m^3/day. Assume the BOD load as 55 gm/capita day.

[8 marks]

(d) An aerated grit chamber is installed for an average wastewater flowrate of 0.3 m^3/s with peak factor of 3.334. The average depth of this chamber is 3 m, the width to depth ratio is 1.5:1, with the peak flow detention time of 3.5 minutes. Calculate the dimensions of the grit chamber.

[6 marks]

(e) A conventional activated sludge process (ASP) is to be used for the treatment of food wastewater which contains high organic matters. Briefly explain the process of microorganisms inside the ASP in decomposing the organic matters for the food wastewater.

[5 marks]

(f) Calculate suitable volume of aeration tank for the following activated sludge process;

F:M = 0.3 kg BOD_5/kg MLSS.day

MLSS = 2,500 mg/L

Organic load = 375 kg/day

[10 marks]

PART B: Answer 2 out of 3 questions

2. (a) Sedimentation tank is one of the important treatment stages in wastewater. **NAME <u>FOUR (4)</u>** types of settling in sedimentation tank and the place of occurrence.

[6 marks]

(b) A rectangular sedimentation tank is designed based on the following data:

Population Equivalent (PE) = 5,000
Depth = 2 m
Horizontal velocity = 2 mm/s

Calculate:

(i) The width of the tank

[7 marks]

(ii) Surface loading rate if length to width ratio is 3:1

[7 marks]

(iii) The dry sludge produced if suspended solid is 300 mg/L and the removal efficiency is 60%

[7 marks]

(c) Sketch a typical flow diagram of primary treatment

[3 marks]

3. (a) Activated sludge is one of the main biological proceses in wastewater treatment. Prove that the return sludge ratio (R) in an activated sludge process can be related as follows:

$x_a = x_R [R/(1+R)]$

where x refers to sludge concentration

[8 marks]

(b) Calculate the oxygen requirement in an aeration tank of an activated sludge process with following design data:

BOD_5 = 250 mg/L (30% is still undegraded on day 5)

Q = 1,500 m^3/day

y = 0.5 mg/mg

k_d = 0.06 day^{-1}

θc = 8 days

[8 marks]

(c) (i) Sketch a typical trickling filter.

[3 marks]

(ii) Calculate the hydraulic load of a trickling filter using the following data:

Q = 5,000 m^3/day

BOD_5 = 250 mg/L

Diameter = 10 m

[6 marks]

(d) An oxidation pond is treating wastewater with following data:

Aerial organic loading = 300 kg BOD_5/ha.day

Q = 3,000 m^3/day

BOD_5 = 250 mg/L

Calculate the surface area of this pond.

[5 marks]

4. (a) Briefly discuss nitrification process in the biodegradation of organic matters.

[5 marks]

(b) A steel industry located in Seberang Prai, Penang is releasing a waste stream containing 30 mg/L of phenol. Assuming that phenol degrades according to the following reaction;

$C_6H_7O + 7.25O_2 \rightarrow 6CO_2 + 3.5H_2O$

(C = 12 g/mole; H = 1 g/mole; O = 16 g/mole)

Calculate the theoretical carbonaceous oxygen demand of this waste stream.

[8 marks]

(c) Design a split rounded pre-cast steel sewer pipe with 70% full of its flow with the peak flow rate of 0.42 m^3/s and the minimum flow rate of 0.0047 m^3/s. Assume the slope as 1:600 and n=0.013. Assume q/Q_{full} = 0.85 and v/V_{full} = 1.14. Calculate the actual peak flow rate when as 100% full flow.

[10 marks]

(d) Application of biosolids to land involves the spreading of biosolids on or just below the soil surface. Discuss the importance of biosolids for land application.

[7 marks]

BAHAGIAN A: Soalan wajib

1. *(a)* *Loji olahan air sisa adalah penting dalam sistem kehidupan moden. Berdasarkan kefahaman anda, huraikan mengenai loji olahan air sisa ini berserta lakaran yang sesuai.*

[6 markah]

(b) *Takrifkan istilah berikut dalam konteks kejuruteraan air sisa:*

(i) *Bahan organik*

(ii) *Beban organik*

[5 markah]

(c) *Hitung nilai keperluan oksigen biologi (BOD) dalam mg/L dari suatu penempatan penduduk seramai 1000 orang dengan kadaralir 225 m^3/hari. Anggap nilai beban BOD 55 g/kapita hari.*

[8 markah]

(d) *Sebuah kebuk kersik berudara dipasang untuk kadaralir air sisa 0.3 m^3/s dengan faktor puncak 3.334. Kedalaman purata kebuk ini adalah 3 m, nisbah panjang kepada kedalaman 1.5:1, dengan masa tahanan pada kadaralir puncak 3.5 minit. Tentukan dimensi kebuk kersik ini.*

[6 markah]

(e) *Sebuah proses enap cemar teraktif konvensional digunakan untuk mengolah air sisa makanan yang mengandungi bahan organik yang tinggi. Terangkan secara ringkas cara mikroorganisma di dalam proses enap cemar teraktif dalam menguraikan bahan organik itu.*

[5 markah]

(f) *Hitung isipadu tangki yang sesuai untuk proses enap cemar teraktif yang berikut:*

F:M	*= 0.3 kg BOD_5/kg MLSS.hari*
MLSS	*= 2,500 mg/L*
Beban organik	*= 375 kg/hari*

[10 markah]

BAHAGIAN B: Jawab 2 dari 3 soalan

2. *(a)* *Tangki enapan merupakan salah satu peringkat penting dalam olahan air sisa.* ***NAMAKAN <u>EMPAT (4)</u>*** *jenis enapan di tangki dan lokasi berlakunya.*

[6 markah]

(b) *Suatu tangki enapan segiempat direka bentuk berdasarkan data berikut:*

Penduduk Setara (PE)	*= 5,000*
Kedalaman	*= 2 m*
Halaju mendatar	*= 2 mm/s*

Hitung:

(i) *Lebar tangki*

[7 markah]

(ii) *Kadar Beban Permukaan jika nisbah panjang kepada lebar 3:1*

[7 markah]

(iii) *Berat kering enap cemar yang terhasil jika pepejal terampai adalah 300 mg/L dengan kecekapan penyingkiran 60%*

[7 markah]

(c) *Lakarkan rajah aliran proses olahan primer tipikal*

[3 markah]

3. *(a)* *Enam cemar terakhir merupakan salah satu proses biologi utama dalam olahan air sisa. Buktikan bahawa nisbah enap cemar kembali (R) dalam proses enap cemar teraktif boleh dihubungkan seperti berikut:*

$x_a = x_R\,[R/(1+R)]$

di mana x merujuk kepada kepekatan enap cemar

[8 markah]

(b) *Hitung keperluan oksigen di tangki pengudaraan proses enap cemar berdasarkan data berikut:*

BOD_5	= 250 mg/L (30% masih tidak terurai pada hari ke 5)
Q	= 1,500 m^3/hari
y	= 0.5 mg/mg
k_d	= 0.06 $hari^{-1}$
θc	= 8 hari

[8 markah]

(c) (i) *Lakarkan turas cucur tipikal*

[3 markah]

(ii) *Kirakan nilai beban hidraulik sebuah turas cucur dengan data berikut:*

Q	= 5,000 m^3/hari
BOD_5	= 250 mg/L
Garis pusat	= 10 m

[6 markah]

(d) *Suatu kolam pengoksidaan mengolah air sisa dengan data berikut:*

Beban organik kawasan	= 300 kg BOD_5/ha.hari
Q	= 3,000 m^3/hari
BOD_5	= 250 mg/L

Hitung luas permukaan kolam ini

[5 markah]

4. (a) *Bincangkan secara ringkas proses nitrifikasi dalam penguraian bahan organik.*

[5 markah]

(b) *Sebuah industri keluli yang berada di Seberang Prai, Pulau Pinang melepaskan aliran sisa yang mengandungi 30 mg/L fenol. Dengan andaian bahawa fenol mendegradasi seperti tindak balas berikut;*

$C_6H_7O + 7.25O_2 \rightarrow 6CO_2 + 3.5H_2O$

(C = 12 g/mol; H = 1 g/mole; O = 16 g/mol)

Hitung keperluan oksigen berkarbon secara teori untuk aliran sisa ini.

[8 markah]

(c) *Reka bentuk pembetung terasing keluli pra-tuang yang mengalir 70% penuh pada kadaralir puncak 0.42 m^3/s dan kadaralir minimum 0.0047 m^3/s. Anggap cerun 1:600 dan n=0.013. Anggap q/Q_{penuh} = 0.85 dan v/V_{penuh} = 1.14. Hitung kadaralir sebenar pada masa 100% penuh.*

[10 markah]

(d) *Penggunaan bio-pepejal di tanah melibatkan penyebaran enap cemar di atas atau di bawah permukaan tanah. Bincangkan kepentingan bio-pepejal untuk penggunaan tanah.*

[7 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 = $\frac{\textit{Kadaralir}}{\textit{Panjang Empang Limpah}}$

Volume of pyramid = (1/3) (base area) (height)

Isipadu Piramid = *(1/3) (luas dasar) (tinggi)*

Organic Load = (Discharge) (BOD)

Beban Organik = *(Kadaralir) (BOD)*

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

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

Kinetik BOD $BOD_t=Lo(1-10^{-k1t})$

$k_T=k_{20}(1.047)^{(T-20)}$

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

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

Beban Organik = (Kadaralir) (BOD)

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

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

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

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

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

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

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

Keperluan Oksigen = aLr + bSa

a = Pekali penyingkiran BOD

Lr = BOD tersingkir

b = pekali endagenous enap cemar

Sa = Jisim Likur Tercampur

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

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

$1/\theta=yu-k_d$

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

Indeks Isipadu Enap cemar (SVI) = (Isipadu MLSS mengenap dalam 30 minit)/MLSS

Tangki Septik, C=225P

Pond design:

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

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

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

Organic Loading = L_iQ/A

Beban Organik = L_iQ/A

Maximum Organic Loading = $7.5 (1.054)^T$

Beban Organik Maksimum = $7.5 (1.054)^T$

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/day

oooOOOooo