UNIVERSITI SAINS MALAYSIA

1st. Semester Examination
2000/2001 Academic Session

SEPTEMBER / OCTOBER 2000

EAP214/3 – Wastewater Engineering & Solid Waste Management

Time : [3 hours]

Instruction to candidates:-

1. Ensure that this paper contains **ELEVEN (11)** printed pages include appendices.

2. This paper contains **SEVEN** (7) question. Answer **FIVE** (5) question only. Marks will be given to the **FIRST FIVE (5)** question put in order on the answer script and **NOT** the **BEST FIVE (5).**

3. All questions carry the same mark.

4. All questions **MUST BE** answered in Bahasa Malaysia.

5. Write answered question number on the cover sheet of answer script.

1. (a) Explain briefly the scenario of domestic wastewater management in Malaysia.
(4 marks)

(b) Give the relation between Organic Loading and Population Equivalent in wastewater treatment.
(3 marks)

(c) Give **THREE (3)** main conditions of siting wastewater treatment plant in residential/commercial area.
(3 marks)

(d) A wastewater from a town with population 2,500 is mechanically screened at the wastewater treatment plant. If the storage period is 5 days at peak flow, using data in Appendix, calculate the maximum surface area of the required screenings tank. Take screen opening as 20 mm and the depth of screenings as 2.5 m.
(7 marks)

(e) If the maximum velocity through the screen in Question 1 (c) is 1 m/minute and bar width is 10 mm, calculate the width of the screen chamber if the depth of wastewater is 1 m.
(3 marks)

2. (a) Three wastewater sample has the same BOD_5 of 200 mg/L but with different k_1 values, i.e., 0.10, 0.15 0.25 day^{-1}.

(i) Determine the ultimate BOD values for each sample. (3 marks)

(ii) Give comments of the obtained value. (2 marks)

(b) A wastewater has the BOD_5 value at 20°C as 240 mg/L. If the k_1 value is 0.1 day^1, determine:

(i) BOD_1 at 13°C.
(ii) BOD_5 at 15°C.
(5 marks)

2. (c) An experiment to determine the ultimate BOD for wastewater at 20°C with 5% dilution has the data as given in Table 1. Saturated Dissolved Oxygen value for dilution water is 9.00 mg/L.

Table 1: BOD experiment data

Day	Final Dissolved Oxygen for Sample (mg/L)	Final Dissolved Oxygen for Control (mg/L)
1	7.10	8.50
2	6.10	8.50
3	5.10	8.40
4	4.20	8.40
5	3.90	8.40
6	3.50	8.30
7	3.00	8.20

Using Thomas Method, determine the L_o and k_1 values for the above sample.

(10 marks)

3. (a) Explain briefly principles of sedimentation tank in treating wastewater.

(4 marks)

(b) A sedimentation tank system is needed for treating wastewater from a residential area based on data as given in Table 2.

Table 2: Design data

Type of Premises	Data
Single-storey medium cost housing	400
Double-storey semi detached houses	100
Double-story shop lots Ground floor – 6.1m x 12.65m Level 1 – 6.1m x 15.54m	40
Petrol station	1
Non-residential school @ 1,500 pupils	1
Surau @ 200 people	1
Wet market @ 30 stalls	1

Based on the data in Appendix, design the above sedimentation tank with sketch. Limit your answer to the dimension, retention time, surface loading rate and weir loading rate.

(10 marks)

3. (c) A residential area with Population Equivalent of 500 people is having the BOD Load of 0.045 kg/day. Determine the suitable dimension of the facultative pond for treating the wastewater if the Aerial Organic Loading is 0.050 kg BOD/m^2.day and the retention time is 20 days. Take length to width ratio of the pond as 3:1.

(6 marks)

4. (a) Define the Sludge Volume Index (SVI). (3 marks)

(b) An aeration tank for an activated sludge process is having the following data:

Volume 250 m^3
Discharge 0.1 m^3/second
Sludge wastage rate 100 m^3/day
Volatile Suspended Solids 285 mg/L
Volume of settled sludge in 30 minutes 200 mL/L
Sludge Volume Index 80 mL/g
Volatile Suspended Solids represents 0.75 of the Suspended Solids

Calculate the sludge age for the above tank.

(7 marks)

(c) Solid wastes can be categorized into domestic organic wastes, combustible wastes, non-combustible wastes, construction and demolition wastes and industrial wastes. List **TWO** (2) types of wastes for each of the above categories.

(4 marks)

(d) Professor Natalya wanted to establish the moisture content and the chemical formula (based on wet weight) of the solid waste (SW) generated at her home. The following datas have been determined by her:-

- Average density = 190 kg/m^3
- Average dry weight of SW = 3.6 kg
- Chemical composition of the SW are as follow:-

	% dry weight
C	46
H	6.2
O	3.4
N	1.6

- Volume of SW container is 0.09 m^3/container. The container's usage factors are as follows:-

Date	Container No.	Usage Factor
July 10	1	0.7
	2	0.6
	3	0.8
July 17	1	0.8
	2	0.7
	3	0.6
July 24	1	0.7
	2	0.6
	3	0.7

- You are required to help the Professor in determining:-
  (i) The SW moisture content.
  (ii) The SW chemical formula.

(6 marks)

5. (a) Solid wastes (SW) generated at Taman Uttama require a proper disposal at landfill site. A truck is used to collect the SW.

(i) How many customers can be served by the truck if each house is serviced 3 times a week and the truck is used 6 times a week? The truck is filled up with SW twice daily.

(ii) What is the compaction ratio of the truck?

The following data have been gathered:-

- Working time : 8 hours
- Travelling time, garage to location : 20 min
- Travelling time to disposal site : 20 min
- Time to empty the truck at disposal site : 12 min
- Travelling time, disposal site to garage : 21 min
- Worker's recess time : 45 min/day
- Volume of truck : 20 m^3
- Volume of SW per service : 0.55 m^3/container
- Travelling time between stopping : 35 second
- Time to unload SW into the truck : 0.5 min/stop
- Each service has 1 container and no collection on Sunday

(8 marks)

(b) With the help of a diagram, explain clearly what is meant by Stationary Collection System in the SW collection analysis.

(2 marks)

(c) What is a transfer station? When is it required? List **FOUR** (4) requirements that need to be considered when designing a transfer station.

(6 marks)

5. (d) Taman Canggai of 55,000 people generate solid waste (SW) at a rate of 0.85kg/capita.day. The initial density of the loose SW is 190 kg/m^3. The SW is collected by 5 trucks a day with a volume of 20m^3/truck. What is the compaction ratio of the trucks and what is the corresponding percent volume reduction of the waste.

(4 marks)

6. (a) A composting plant at Putera Layar City received solid wastes from 350,000 population. The waste generation rate is 1.2kg/capita.day. After segregation, it was found that organic fraction of the waste amounted to 55% of the total solid waste generated with moisture content of 45%. Further research on the organic fraction (OF) was carried out and it was concluded that the chemical formula = C_{45} H_{55} O_{25} N and the carbon and nitrogen content is 45% and 7% respectively.

(i) List **FOUR** (4) factors that influence composting process and briefly explain how these factors affect the composting process.

(4 marks)

(ii) Estimate the air volume required to degrade the OF of the waste if the air contain 21% oxygen and the air specific weight is 1.125 kg/m^3.

(4 marks)

(iii) Estimate the garden waste quantities that should be added to the OF to achieve a C/N ratio of 35. The following datas are given:-

- $\frac{C}{N}$ of garden waste = 8.5
- Nitrogen content of garden waste = 0.7%
- Moisture content of garden waste = 55%

(4 marks)

(b) Briefly discuss **FOUR** (4) factors that influence the success of recycling program.

(4 marks)

(c) Differentiate between incineration and pyrolisis in terms of:-

(i) Solid waste residual and gas production.
(ii) Mode of operation.

(4 marks)

7. (a) Write a short notes on landfill gas. Your notes should include:-

(i) Chemical reaction for the gas generation.
(ii) Factors that influence the gas generation.
(iii) Negative impacts of landfill gas to the environment.
(iv) The gas control systems with appropriate sketches.

(10 marks)

7. (b) You are required to estimate the following:-

(i) Total volume of intermediate cover and list two (2) of its functions.
(ii) Life-span of landfill (inclusive of intermediate cover),

based on the following data:-

- Waste generation rate = 0.85 kg/capita.day.
- Population = 75,000 people.
- Compacted waste density = 370 kg/m^3.
- The final height of landfill = 6 m.
- Depth of intermediate cover = 0.001 m/day.
- Existing area of landfill = 115,000 m^2.

(5 marks)

(c) (i) Estimate the volume of leachate generated from a landfill site with an area of 40,000m^2 if the following data are given:-

- Rainfall = 1.2 m/month
- Evaporation = 0.15 m/month
- Compacted waste density = 365 kg/m^3
- Volume of waste = 750 m^3/month
- Absorptive capacity = 0.15 m^3/kg of waste

(2 marks)

(ii) Why does leachate require treatment prior disposal to the environment? What kind of treatments are required to treat 'young' leachate?

(3 marks)

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APPENDIX

Faktor Puncak = $4.7\ p^{-0.11}$ (p dalam ribu)

Masa tahanan = Isipadu /kadaralir

Penduduk Setara = $\frac{\text{Beban Organik Premis}}{\text{Beban Organik 1 orang}}$

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

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

$R=A/P$

Lebar saring = $\frac{\text{(Lebar bilah + saiz bukaan)}}{\text{Saiz bukaan}}\ \frac{\text{(Kadaralir)}}{\text{(Halaju) (Kedalaman air sisa)}}$

Sela pengepaman = $\frac{\text{Isipadu sebenar}}{\text{Kadaralir Cuaca Kering}} + \frac{\text{Isipadu sebenar}}{\text{(Kadar pam-Kadaralir Cuaca Kering)}}$

Kadar Beban Permukaan = $\frac{\text{Kadaralir}}{\text{Luas Permukaan}}$

Kadar Beban Pepejal = $\frac{\text{(Kadaralir) (Likur Tercampur)}}{\text{Luas Permukaan}}$

Kadar Beban Empang Limpah = $\frac{\text{Kadaralir}}{\text{Panjang Empang Limpah}}$

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

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

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

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

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

Beban Organik = (Kadaralir) (BOD)

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APPENDIX

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 = $\frac{1}{1+kd\theta c}$ (Kadaralir)(BOD)

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

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

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

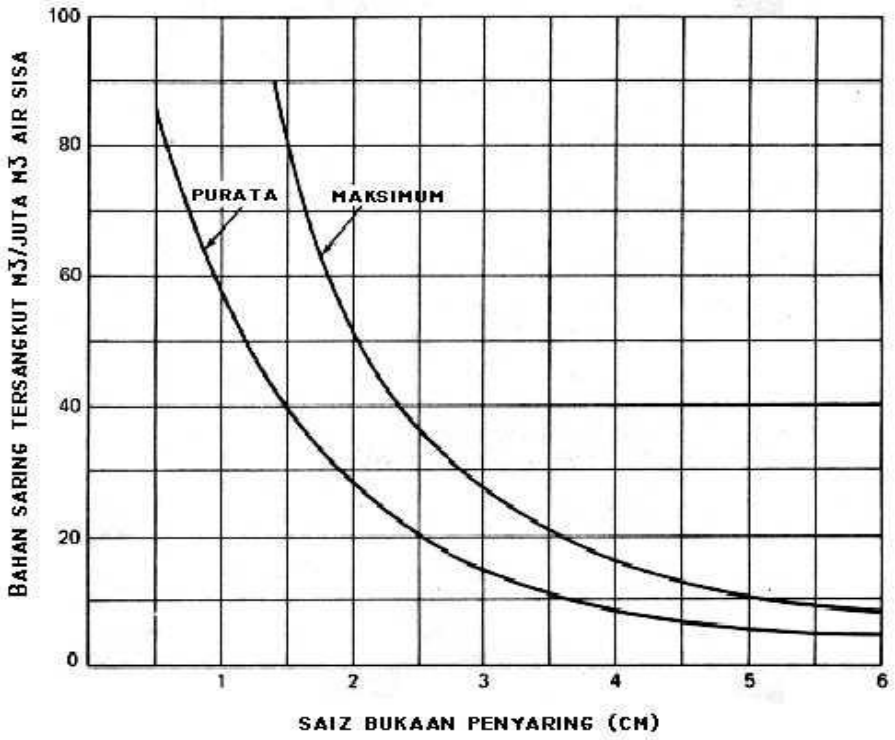
$1/\theta=yu-k_d$

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

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

Tangki Septik, C=225P

APPENDIX



Kuantiti bahan saring yang dikumpul oleh penyaring mekanik

Parameter reka bentuk tangki enapan

Parameter	Unit	Kriteria Reka bentuk
Kadaralir	(m^3/hari)	$Q_{puncak} = 4.7\ p^{-0.11}$ kck
Masa tahanan minimum pada Q_{puncak}	(jam)	1.5 - 2.0
Kadar Beban Permukaan (KBP) pada Q_{puncak}	m^3/m^2.hari	
Bulat (< 50m diameter dan kedalaman 3.0 m)		< 45
Segiempat		< 30
Kadaralir Keluar Empangan Limpah (KKEL) pada Q_{puncak}	m^3/m.hari	100 < KKEL < 200
Halaju horizontal (melintang)	mm/s	< 15
Nisbah Panjang: Lebar	-	3:1
Kedalaman tangki:		
Tangki horizontal	m	2.0 - 3.5
Tangki jejari	m	> 1.5
Mengalir ke atas (piramid)	m	5.0 - 9.0
Cerun kepada horizontal	Darjah	< 60 (piramid) < 45 (jejari)

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APPENDIX

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