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UNIVERSITI SAINS MALAYSIA

1st. Semester Examination  
2003/2004 Academic Session  
*Peperiksaan Semester Pertama  
Sidang Akademik 2003/2004*

**September / October 2003**

**EAP 313/2 - Wastewater Engineering**  
*EAP 313/2 – Kejuruteraan Air Sisa*

**Duration : 3 hours**  
*Masa : 3 jam*

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**Instructions to candidates:**

*Arahan kepada calon:*

1. Ensure that this paper contains **THIRTEEN (13)** printed pages including appendices.  
*Sila pastikan kertas peperiksaan ini mengandungi TIGA BELAS (13) muka surat bercetak termasuk lampiran sebelum anda memulakan peperiksaan ini.*
2. This paper contains **SIX (6)** questions. Answer **FIVE (5)** questions only. Marks will be given to the **FIRST FIVE (5)** questions put in order on the answer script and **NOT** the **BEST FIVE (5)**.  
*Kertas ini mengandungi ENAM (6) soalan. Jawab LIMA (5) soalan sahaja. Markah hanya akan dikira bagi LIMA (5) jawapan PERTAMA yang dimasukkan di dalam buku mengikut susunan dan bukannya LIMA (5) jawapan terbaik.*
3. All questions carry equal marks.  
*Tiap-tiap soalan mempunyai markah yang sama.*
4. Questions **CAN BE** answered either in English or Bahasa Malaysia or a combination of both languages.  
*Semua soalan boleh dijawab dalam Bahasa Inggeris atau Bahasa Malaysia ataupun kombinasi kedua-dua bahasa.*
5. Each question **MUST BE** answered on a new page.  
*Semua jawapan MESTILAH dimulakan pada muka surat yang baru.*
6. Write the answered question numbers on the cover sheet of the answer script.  
*Tuliskan nombor soalan yang dijawab di luar kulit buku jawapan anda.*

1. (a) Give the relation between Organic Loading and Population Equivalent in wastewater treatment.

( 3 marks)

*Berikan hubungan di antara Beban Organik dan Penduduk Setara dalam olahan air sisa.*

- (b) Give **THREE** (3) main conditions of siting an open wastewater treatment plant in residential area.

( 3 marks)

*Berikan **TIGA** (3) syarat utama dalam menempatkan loji olahan air sisa terbuka di kawasan perumahan.*

- (c) A sewer with diameter 1.0 m is flowing a wastewater from a housing estate. If wastewater inside the sewer flows 70% full, ratio of sewage to supplied water is 0.75, allowable slope 1:650, calculate the maximum number of houses contributed to the wastewater in the sewer. Take  $n = 0.013$ .

( 8 marks)

*Suatu pembedung berdiameter 1.0 m sedang mengalirkan air sisa dari suatu kawasan perumahan. Sekiranya pembedung mengalir 70% penuh, nisbah air sisa:air dibekal 0.75, cerun dibenarkan 1:650, kirakan bilangan maksimum rumah yang menyumbang terhadap aliran air sisa ini. Ambil  $n = 0.013$ .*

- (d) Given that the value of  $BOD_5$  load for Taman Anggun in Ipoh is 150 kg/day. The Taman Anggur has a total number of 200 houses and a mosque which can accommodate 200 person. Calculate the  $BOD_5$  value of this wastewater.

( 6 marks)

*Diberi bahawa nilai Beban  $BOD_5$  untuk Taman Anggun di Ipoh adalah 150 kg/hari. Taman Anggur mempunyai sebanyak 200 rumah dan sebuah masjid untuk 200 orang. Kirakan nilai  $BOD_5$  air sisa ini.*

2. (a) Discuss the importance of pH and  $BOD_5$  in biological treatment of wastewater.

( 4 marks)

*Bincangkan kepentingan pH dan  $BOD_5$  dalam olahan biologi air sisa.*

- (b) A wastewater from a town with population 2,500 is mechanically screened at the wastewater treatment plant. If the maximum surface area of the required screenings tank is  $0.24 \text{ m}^2$ , using data in Appendix, calculate the storage period of this tank. Take screen opening as 20 mm and the depth of screenings as 2.5 m.

( 7 marks)

*Air sisa dari suatu Bandar dengan penduduk 2,500 orang disaring secara mekanik di loji olahan. Sekiranya luas permukaan maksimum tangki bahan saring adalah  $0.24 \text{ m}^2$ , menggunakan data di Lampiran, kirakan masa penstoran tangki ini. Ambil saiz bukaan penyaring sebagai 20 mm dan kedalaman tangki 2.5 m.*

- (c) Name **THREE** (3) main types of pump, normally used in wastewater treatment plant. ( 3 marks)

Namakan **TIGA** (3) jenis utama pam, biasanya digunakan di loji olahan air sisa.

- (d) Design a suitable pump sump for a housing scheme with the information given in Table 1:

**Table 1: Design data**

| Type of premises   | Unit  |
|--|-------|
| Single storey medium cost  | 1,000 |
| Double storey semi-detached  | 500   |
| Double storey shop lots<br>Ground floor – 6.1m x 12.65m<br>First floor – 6.1m x 15.54m | 50    |
| Petrol station   | 1     |
| Daily school without hostels @ 1,500 pupils  | 1     |
| Mosque @ 1,000 people  | 1     |
| Dry market @ 30 shops  | 1     |

Take retention time at  $Q_{peak}$  as 30 minutes.

( 6 marks)

- (d) *Rekabentukkan kebuk pam yang sesuai untuk suatu kawasan perumahan menggunakan data dalam Jadual 1:*

**Jadual 1: Data reka bentuk**

| Jenis premis   | Unit  |
|--|-------|
| Rumah setingkat kos sederhana  | 1,000 |
| Rumah berkembar dua tingkat  | 500   |
| Lot kedai dua tingkat<br>Paras lantai – 6.1m x 12.65m<br>Tingkat pertama – 6.1m x 15.54m | 50    |
| Stesyen petrol   | 1     |
| Sekolah harian tanpa asrama @ 1,500 murid  | 1     |
| Masjid @ 1,000 orang   | 1     |
| Pasar kering @ 30 gerai  | 1     |

*Ambil masa tahanan pada  $Q_{puncak}$  sebagai 30 minit.*

3. (a) Prove that the design of sedimentation tank is independent from the tank's depth. ( 6 marks)

*Buktikan bahawa reka bentuk tangki enapan tidak bergantung kepada kedalaman tangki.*

- (b) A wastewater from a new housing scheme, with 5,000 population equivalent is required to be physically treated at the primary sedimentation tank. Calculate the volume of wet sludge in  $m^3$  from the tank if the suspended solids reading at influent is 350 mg/L. Assume the tank's efficiency as 70% and the specific gravity value of the wet sludge is 1.03. Take storage period of sludge in the tank as 7 days. ( 6 marks)

*Air sisa dari suatu skim perumahan baru dengan penduduk setara 5,000 orang perlu diolah secara fizikal di tangki enapan. Kirakan isipadu enap cemar basah dalam  $m^3$  di tangki ini sekiranya nilai pepejal terampai di influen adalah 350 mg/L. Anggap kecekapan tangki sebagai 70% dan nilai graviti tentu enap cemar basar 1.03. Ambil masa penstoran enap cemar dalam tangki sebagai 7 hari.*

- (c) A housing scheme has the population data as given in Table 2.

**Table 2: Design Data**

| Types of premises           | Unit |
|-----------------------------|------|
| Single storey terrace house | 500  |
| Double storey terrace house | 500  |
| Semi-detached house         | 50   |
| Bungalow house              | 20   |

- Calculate the volume and surface overflow rate of this tank. ( 8 marks)

*Suatu skim perumahan mempunyai data penduduk seperti diberikan di Jadual 2.*

**Jadual 2: Data reka bentuk**

| Jenis premis             | Unit |
|--------------------------|------|
| Rumah teres satu tingkat | 500  |
| Rumah teres dua tingkat  | 500  |
| Rumah berkembar          | 50   |
| Rumah bungalow           | 20   |

*Kirakan isipadu serta kadar alir permukaan tangki ini.*

4. (a) With the help of a diagram, explain the effect of temperature on the BOD reaction rate constant.

( 2 marks)

*Dengan bantuan gambarajah, terangkan kesan suhu terhadap pemalar kadar BOD.*

- (b) Differentiate between aerobic, anaerobic and facultative bacteria. ( 3 marks)

*Bezakan di antara bakteria aerobik, anaerobik and fakultatif.*

- (c) The 5-day BOD of a wastewater sample incubated at 20°C is 300mg/L. Assuming the reaction rate constant at this temperature to be 0.23 per day, calculate the 3-day BOD of the wastewater if the test were conducted at 30°C.

( 5 marks)

*Nilai BOD<sub>5</sub> sampel air sisa yang dieramkan pada suhu 20°C is 300 mg/L. Dengan menganggap pemalar kadar BOD pada suhu ini 0.23 hari<sup>-1</sup>, kirakan nilai BOD 3 hari sekiranya ujian dijalankan pada suhu 30°C.*

- (d) Using a method of your choice, determine the ultimate BOD ( $L_0$ ) and the reaction rate constant ( $k$ ) from the following set of BOD data:

|           |     |     |     |     |     |
|-----------|-----|-----|-----|-----|-----|
| Time, d   | 1   | 2   | 3   | 4   | 5   |
| BOD, mg/L | 120 | 200 | 270 | 320 | 370 |

(10 marks)

*Menggunakan kaedah pilihan anda, tentukan nilai BOD muktamad ( $L_0$ ) dan nilai pemalar kadar BOD ( $k$ ) dari set data BOD berikut:*

|           |     |     |     |     |     |
|-----------|-----|-----|-----|-----|-----|
| Masa, d   | 1   | 2   | 3   | 4   | 5   |
| BOD, mg/L | 120 | 200 | 270 | 320 | 370 |

5. (a) What are suspended growth and attached growth biological treatment processes? ( 2 marks)

*Apakah yang dimaksudkan dengan proses olahan biologi kultur terampai.*

5. (b) Briefly explain the working of the following:
- (i) Activated Sludge Process or Oxidation Pond. ( 4 marks)
  - (ii) Rotating Biological Contactor or Trickling Filter. ( 4 marks)

*Terangkan secara ringkas prinsip kerja berikut:*

- (i) Proses enapcemar teraktif atau kolam pengoksidaan.*
- (ii) Penyentuh Biologi Berputar atau turas cucur.*

- (c) 20,000 m<sup>3</sup>/d of municipal wastewater is to be treated by the activated sludge process (ASP). The influent BOD to the ASP is 180 mg/L. As required, the effluent from the ASP should have a soluble BOD of not more than 10 mg/L.

Assumptions:

Mixed liquor suspended solids (MLSS) = 3 000 mg/L

Mean cell residence time = 10 d

Return sludge from secondary settling tank = 10 000 mg/L

Yield coefficient = 0.5 kg/kg

Endogenous decay rate constant = 0.05

Determine:

- (i) the volume of aeration tank. ( 3 marks)
- (ii) the mass and volume of sludge to be wasted per day. ( 4 marks)
- (iii) the recycle ratio. ( 3 marks)

*20,000 m<sup>3</sup>/hari air sisa perbandaran perlu diolah secara proses enapcemar teraktif (ASP) Nilai influen BOD ke ASP adalah 180mg/L. Seperti disyaratkan, efluen dari ASP perlu mengandungi BOD larut tidak melebihi 10mg/L.*

*Anggapan:*

*Likur campuran Pepejal Terampai (MLSS) = 3,000 mg/L.*

*Masa tahanan pepejal = 10 hari.*

*Enapcemar kembali dari tangki enap sekunder = 10,000 mg/L.*

*Pekali pembiakan = 0.5 kg/kg*

*Pekali kematian endogenous = 0.05.*

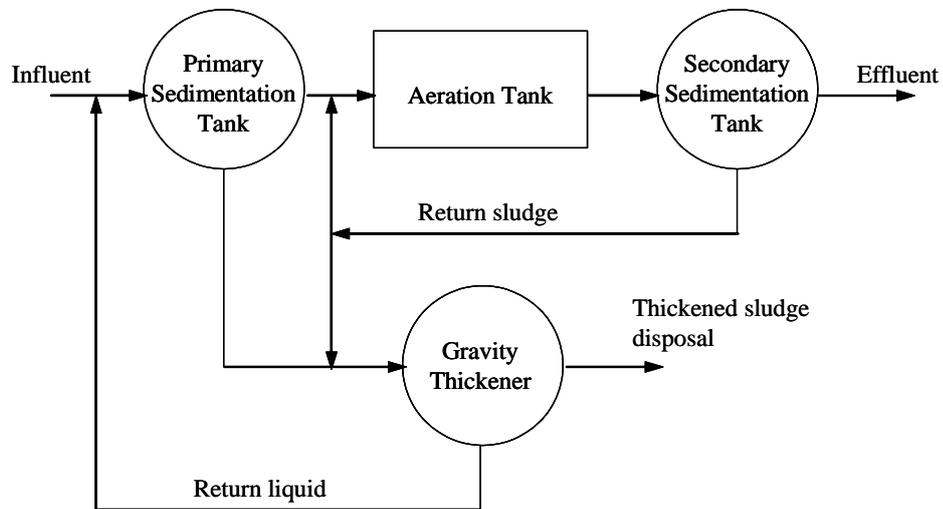
*Tentukan:*

- (i) Isipadu tangki pengudaraan.*
- (ii) Jisim dan isipadu enapcemar yang perlu disingkirkan setiap hari.*
- (iii) Nisbah enapcemar kembali.*

6. (a) Describe in detail **TWO** (2) processes of sludge treatment. (10 marks)

*Terangkan dengan jelas **DUA** (2) proses untuk olahan enapcemar.*

- (b) Municipal wastewater is treated in a treatment plant whose schematic diagram is shown in Figure 1.



**Figure 1**

Characteristics of the treatment plant, wastewater and sludges are:

Treatment plant:

Diameter of primary sedimentation tank = 30 m  
 Volume of aeration tank = 4 000 m<sup>3</sup>  
 Mixed liquor suspended solids in aeration tank = 3 500 mg/L

Wastewater:

Influent suspended solids = 200 mg/L  
 Influent BOD = 250 mg/L  
 Effluent BOD = 20 mg/L  
 Flow = 30 000 m<sup>3</sup>/d

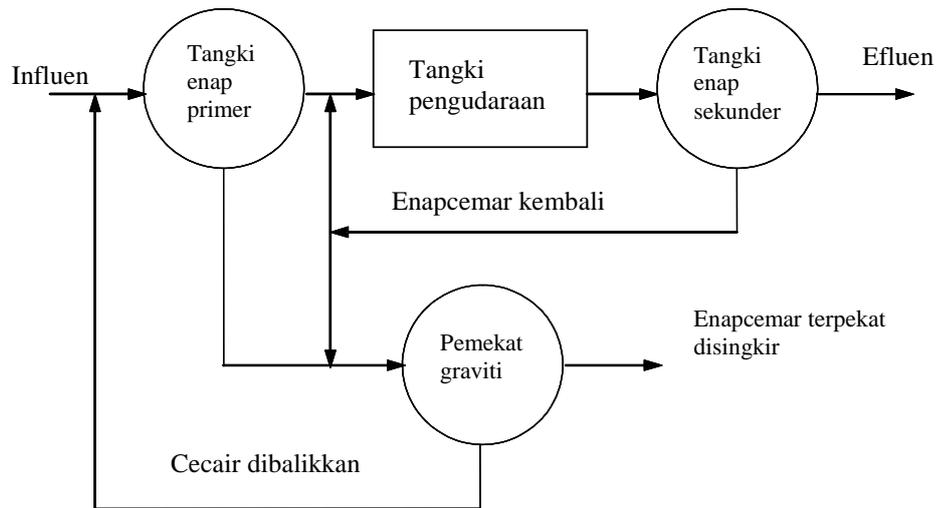
Sludge solids:

Primary sedimentation tank = 4.5 %  
 Secondary sedimentation tank = 1.0 %  
 Gravity thickener = 8 %

Determine:

- (i) the mass and volumetric loading rates to the thickener. (8 marks)  
 (ii) the percent volume reduction by the gravity thickener. (2 marks)

(b) Air sisa perbandaran diolah di loji olahan seperti rajah skema di Rajah 1.



**Rajah 1**

Ciri-ciri loji olahan, air sisa dan enapcemar adalah:

Loji Olahan:

Diameter tangki enap primer = 30m

Isipadu tangki pengudaraan = 4,000 m<sup>3</sup>

Likur campuran Pepejal Terampai di tangki pengudaraan = 3,500 mg/L

Air Sisa:

Pepejal Terampai di influen = 200 mg/L

BOD influen = 250 mg/L

BOD influen = 20 mg/L

Kadar alir = 30,000 m<sup>3</sup>/hari

Pepejal enapcemar:

Tangki enap primer = 4.5%

Tangki enap sekunder = 1.9%

Pemekat graviti = 8%

Tentukan:

(a) Kadar beban jisim dan kadar beban isipadu ke pemekat.

(b) Peratus pengurangan isipadu oleh pemekat graviti.

**APPENDIX**

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 =  $(1/3) (\text{luas dasar}) (\text{tinggi})$

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

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

APPENDIX

**Table 5.8 Design Parameters for Primary Sedimentation**

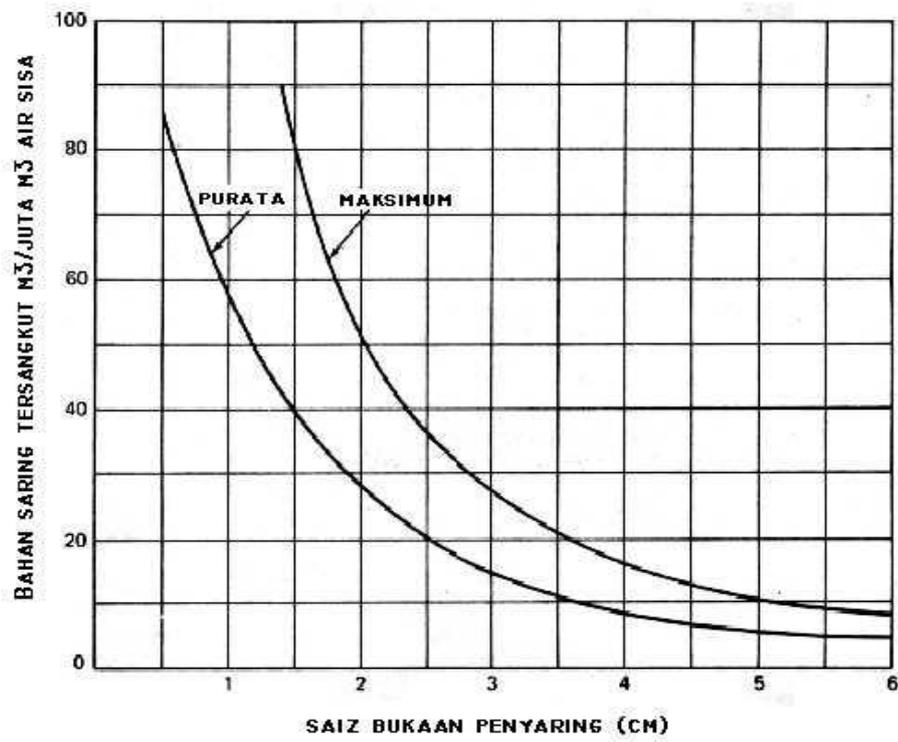
| Description  | Unit        | Design Criteria  |
|--|-------------|------------------|
| <b>Sedimentation followed by secondary treatment</b> |             |                  |
| Detention time at $Q_{peak}$                         | hr          | 2                |
| Surface overflow rate at $Q_{peak}$                  |             | 30 - 45          |
| - circular (maximum)*                                | $m^3/m^2/d$ | 45               |
| - rectangular (maximum)                              | $m^3/m^2/d$ | 30               |
| Weir loading at $Q_{peak}$                           | $m^3/m/d$   | 100 min, 200 max |
| Upward flow rate at $Q_{peak}$                       | m/hr        | 1.2 - 2.0        |
| <b>Sedimentation with RAS return</b>                 |             |                  |
| Detention time at $Q_{peak}$                         | hr          | 1.5 - 2.0        |
| Surface overflow rate at $Q_{peak}$                  |             |                  |
| - Circular (maximum)*                                | $m^3/m^2/d$ | 40               |
| - Rectangular (maximum)                              | $m^3/m^2/d$ | 30               |
| Weir loading at $Q_{peak}$                           | $m^3/m/d$   | 100 min, 200 max |
| Upward flow rate at $Q_{peak}$                       | m/hr        | 1.3 - 1.7        |
| <b>Sizing of rectangular tanks</b>                   |             |                  |
| Length : Width                                       |             | 3:1              |

\* Circular tanks shall be no more than 50 m in diameter and the side water depth shall be at a minimum of 3.0 m.

**Note:** If weir loading exceeds 100  $m^3/day/m$  at average flow, a multiple v-notch weir must be used.

Refer also to Clause 6.3.6 of MS 1228.

APPENDIX



Screen designing chart  
Carta reka bentuk penyaring

**APPENDIX**

**Table B.1 Recommended Population Equivalent Factors**

| <b>Type of Premise/Establishment</b>  | <b>Population Equivalent (recommended)</b>  |
|---|---|
| Residential   | 5 per house   |
| Commercial (includes offices, shopping complex, entertainment/recreational centres, restaurants, cafeteria, theaters)   | 3 per 100 m <sup>2</sup> gross area   |
| Schools/Educational Institutions:<br><ul style="list-style-type: none"> <li>- Day schools/institutions</li> <li>- Fully residential</li> <li>- Partial residential</li> </ul> | 0.2 per student<br>1 per student<br>0.2 per student for non residential student and 1 per student for residential student |
| Hospitals   | 4 per bed   |
| Hotels (with dining and laundry facilities)   | 4 per room  |
| Factories (excluding process water)   | 0.3 per staff   |
| Market (wet type)   | 3 per stall   |
| Petrol Kiosks/Service Stations  | 18 per service bay  |
| Bus Terminal  | 4 per bus bay   |
| Taxi Terminal   | 4 per taxi bay  |
| Mosque  | 0.5 per person  |
| Church/Temple   | 0.2 per person  |
| Stadium   | 0.2 per person  |
| Swimming Pool/Sports Complex  | 0.5 per person  |
| Public Toilet   | 16 per wc   |
| Type of Premise/Establishment   | Population Equivalent (recommended)   |
| Airport   | 0.2 per passenger<br>0.3 per employee   |
| Laundry   | 10 per machine  |
| Prison  | 1 per person  |
| Golf Course   | 20 per hole   |

**APPENDIX**

$$\text{BOD} = L_0(1 - e^{-kt})$$

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

Least-squares method for BOD constants determination,

$$na + b\Sigma y - \Sigma y' = 0$$

$$a\Sigma y + b\Sigma y^2 - \Sigma yy' = 0$$

Relationships for mean cell residence time,

$$\theta_c = \frac{VX}{Q_w X_r}$$

$$\frac{1}{\theta_c} = \frac{QY(S_0-S)}{VX} - k_d$$

Hydraulic retention time  $\theta = \frac{V}{Q}$

$$\frac{F}{M} = \frac{Q(S_0-S)}{VX}$$