Section 2

Design Overview
2.1 **Treatment Plant Classification**

2.1.1 **Classification by Biological Treatment Processes**

The microorganisms in sewage treatment can be grown in a form of fixed film, suspension or a combination of both. Hence, biological treatment processes for sewage treatment works can be classified under one of the following headings:

a) Attached Growth Processes
b) Suspended Growth Processes
c) Combined Processes (Hybrid)

2.1.1.1 **Attached Growth Processes**

In an attached growth process, the active microorganisms grow and attach on the mobile or immobile medium (rock or plastic) that is in contact with sewage. The surface area of the biomass is used as the practical measure of the total organism activity. Types of attached growth processes include:

a) Trickling Filter (TF)
b) Rotating Biological Contactor (RBC)
c) Submerged Biological Contactor (SBC)
d) Fluidised Bed
e) Packed Bed Reactor

2.1.1.2 **Suspended Growth Processes**

In a suspended growth process, active microorganisms remain in suspension in the sewage and their concentration is usually related to mixed liquor suspended solid (MLSS) or mixed liquor volatile suspended solid (MLVSS). This system was developed as a result of studies that showed that if sewage is aerated over a long period of time, the organics in the sewage are removed by the active microorganisms grow during the process.

Types of suspended growth processes include:

a) Waste Stabilisation Pond System
b) Aerated Lagoon
c) Conventional Activated Sludge (CAS)
2.1.1.3 Hybrid Processes - Attached Growth with Suspended Growth

Recent developments in sewage treatment technology include the combination of various attached growth and suspended growth processes to obtain the best performance and most economical treatment of sewage.

One of the advantages of Hybrid Process is the process combines the stability and resistance to shock loads of an attached growth process and the capability to produce high-quality effluent of an suspended growth system.

Hybrid processes can be used to upgrade existing attached growth and suspended growth process, in particularly plants with high suspended solids in the final effluent due to poor solids settlement in the final clarifier.

2.1.2 Classification by Treatment Plant Capacity

Sewage treatment plants are also classified in accordance to the design capacity in terms of population equivalent (PE). Table 2.2 tabulates 4 clarifications to be adopted.

<table>
<thead>
<tr>
<th>Classification</th>
<th>PE</th>
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<tbody>
<tr>
<td>Class 1</td>
<td>≤1000</td>
</tr>
<tr>
<td>Class 2</td>
<td>1001 – 5000</td>
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<tr>
<td>Class 3</td>
<td>5001 – 20000</td>
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<tr>
<td>Class 4</td>
<td>&gt; 20000</td>
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</tbody>
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2.2 Treatment System Selection / Design

2.2.1 General Selection Considerations

The following factors must be considered when selecting a sewage treatment process:
<table>
<thead>
<tr>
<th>Process</th>
<th>The applicability of a process is evaluated on the basis of past experience, data from full-scale plants and pilot data from treatment plant studies. If new or unusual conditions are encountered, pilot-plant studies are necessary.</th>
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</thead>
<tbody>
<tr>
<td>Flow Range</td>
<td>The selected process should be matched to the expected flow range.</td>
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<tr>
<td>Flow Variation</td>
<td>Most unit operation and processes work best with a constant flow rate, although some variation can be tolerated. If the flow variation is too great, flow equalisation may be necessary.</td>
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<tr>
<td>Influent Sewage</td>
<td>The characteristics of the influent will affect the types of processes to be used and the requirements for their proper operation.</td>
</tr>
<tr>
<td>Inhibiting Constituents</td>
<td>Identify the constituents present that may be inhibitory, and the conditions they are in.</td>
</tr>
<tr>
<td>Climatic Constraints</td>
<td>Temperature affects the rate of reaction of most treatment processes.</td>
</tr>
<tr>
<td>Reaction Kinetics and Reactor Selection</td>
<td>Reactor sizing is based on the governing reaction kinetics. Data for kinetic expressions are usually derived from experience, literature and results of pilot-plant studies.</td>
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<tr>
<td>Performance</td>
<td>Performance is usually measured in terms of effluent quality, which must be consistent with the given effluent discharge requirements.</td>
</tr>
<tr>
<td>Treatment Residuals</td>
<td>The types and amounts of solid, liquid and gaseous residuals produced must be known or estimated.</td>
</tr>
<tr>
<td>Sludge Handling Constraints</td>
<td>In many cases, a treatment method should be selected only after the sludge processing and handling options have been explored.</td>
</tr>
<tr>
<td>Environmental Constraints</td>
<td>Nutrient requirements must be considered for biological treatment processes. Environmental factors, such as the prevailing winds and wind directions, may restrict the use of certain processes, especially where odours may be produced.</td>
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</tbody>
</table>
## Design Overview

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Description</th>
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<tbody>
<tr>
<td><strong>Chemical Requirements</strong></td>
<td>Classify chemicals and amounts that must be committed for a long period of time for the successful operation of the unit operation or process.</td>
</tr>
<tr>
<td><strong>Energy Requirements</strong></td>
<td>The energy requirements, as well as probable future energy costs, must be known if cost-effective treatment systems are to be designed.</td>
</tr>
<tr>
<td><strong>Other Resource Requirements</strong></td>
<td>Identify additional resources that must be committed to the successful implementation of the proposed treatment system using the unit operation or process in question.</td>
</tr>
<tr>
<td><strong>Reliability</strong></td>
<td>Consider the long-term record of the reliability of the unit operation or process under consideration.</td>
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<tr>
<td><strong>Complexity</strong></td>
<td>Evaluate the complexity of the process to operate under routine conditions and under emergency conditions such as shock loadings, as well as the level of training the operator must have to operate the process.</td>
</tr>
<tr>
<td><strong>Ancillary Processes</strong></td>
<td>Identify the required support process and the effect on the effluent quality, especially when they become inoperative.</td>
</tr>
<tr>
<td><strong>Compatibility</strong></td>
<td>The unit operation or process shall be used successfully with existing facilities, plant expansion and modifications.</td>
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<tr>
<td><strong>Odour and Noise</strong></td>
<td>Odour and noise pollution should be minimised to the lowest possible level.</td>
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<tr>
<td><strong>Aesthetics</strong></td>
<td>The selected treatment process should aesthetically suit the development site.</td>
</tr>
<tr>
<td><strong>Safety and Operability</strong></td>
<td>The chosen treatment process shall be designed with utmost care to facilitate safe operations at all times as well as to incorporate safety features for the protection of operators. See Section 2.3.</td>
</tr>
</tbody>
</table>
**Land Requirements**

A more compact plant component may perform equally well to a component taking up more land and thus would be preferential, provided there was no significant component cost differences.

**Ease of Operation and Maintenance**

This will dictate whether plant has to be continuously or intermittently operated and whether skilled or relatively unskilled personnel would be required to carry out the operations and maintenance works.

**Modulation**

Modulation refers to the ability of process units to be expanded in tandem with flow increases. Modulation minimises the time that the plant sits idle before utilisation and lowers initial capital outlay.

**Standardisation**

This brings about economics on design effort, material procurement, quality checks, spares and maintenance costs.

**Adaptability**

Adaptability refers to the ability to readily upgrade or uprate the performance of a treatment plant with relatively minor extra works.

**Sludge Management**

This is an important aspect that needs careful evaluation. Treatment systems that minimise waste sludge production, and which produce a relatively stable sludge should be given preference. See Section 5.12

**Overall Cost**

This will include considerations of capital, operation and maintenance costs. Spare parts costs related to maintenance can be hidden costs that also need consideration, particularly where there may be long time delays obtaining parts or specialist inputs are required.
2.2.2 Design Stages

The design of a sewage treatment plant comprises the following stages:

Process Design  In this stage, a suitable sequence of processes are selected to meet stipulated final effluent requirements for the plant concerned.

Functional Design  In this stage, calculation of capacities required are conducted for all major units, channels, pumps and pipework and also definition of control requirements. These include designs for hydraulic, organic and solid loadings.

Detailed Design  In this stage, structural design of units and channels, detailing of pipelines, fittings and control valves, and selection of mechanical, electrical and control equipment are conducted.

2.2.3 Detailed Design Criteria

For the following characteristics and requirements of a treatment plant, the designer needs to consider a number of detailed design criteria:

a) Biochemical characteristics
b) Physical characteristics
c) Hydraulic characteristics
d) Mechanical & engineering requirements
e) Structural requirements
f) Constructional characteristics

2.2.3.1 Biochemical Characteristics

These involve the consideration of the following parameters:

a) Chemical characteristics of sewage
b) Good activity between microorganisms and waste materials
c) Optimal substrate concentration
d) Operational stability (half-life and activity decay profile)
e) Availability of suitable nutrients
f) Maintenance of favourable environment
g) Effect of filamentous growth & sludge bulking
h) Effect of dissolved oxygen
i) Productivity in lifetime usage
j) Minimum and maximum residence times
k) By-product formation
l) pH and temperature sensitivity
m) Storage stability
n) Reactor effluent quality—composition, colour, odour, etc.
o) Sludge production and frequency of desludging
p) Effective material balance analysis
q) Development of biochemical kinetic coefficient through pilot plants

2.2.3.2 Physical Characteristics

These involve the examination of:

a) Particle shape and size distribution
b) Dry and wet bulk density
c) Swelling behaviour
d) Compressibility
e) Cohesion and particle attrition
f) Settlement
g) Floc formation
h) Settling velocity and sedimentation

2.2.3.3 Hydraulic Characteristics

These involve the examination of:

a) Hydraulic velocities in all unit processes
b) Mode of flow, upflow versus downflow
c) Axial dispersion and channelling
d) Pressure drop and head loss through plant
e) Residence time distribution and retention time
f) Stratification
g) Length to width ratio
h) Minimum velocity for onset of fluidisation
Design Overview

i) Weir loadings
j) Overflow rate

2.2.3.4 Construction Characteristics

These involve the examination of:

a) Ground conditions and soil characteristics
b) Land availability
c) Type of plant depending on density and type of community to be served
d) Distance to nearest habitation
e) Delivery and construction time
f) Recommended maintenance requirements
g) Start-up time and procedure
h) Noise levels
i) Technical capability to construct, operate and maintain the system

2.2.3.5 Structural Requirements

a) Wall, slab, beams, columns and structure for sewage treatment plant shall be in reinforced concrete.
b) Wall shall have minimum thickness of 225 mm.
c) Special foundation shall be provided where necessary.
d) Proper jointing to prevent breakage and leakage.
e) Water retaining and slope protection where applicable.

2.2.3.6 Mechanical & Electrical Requirements

a) The design shall simplify the equipment required, control system, maintenance and operational procedures, while fulfilling the intended performance and standard of service.
b) Equipment selected shall be from manufacturers (and models) approved by the Commission.
c) Equipment, cable and cabling design and installation shall follow IEE and TNB requirements.
d) Foundations shall be structurally designed and anchored to withstand all loads imposed by the equipment. Reinforced concrete foundations are preferred.
e) Joints shall be provided in all piping to allow removal of equipment, meters, valves and other special items without causing dismantling of the pipeline.

f) Equipment shall be equipped with safety protection (i.e. emergency stop button, warning signage & etc.). See Section 4.5.

g) Pipeworks shall be neatly arranged and properly supported.

h) Appropriate type of control system provided for the treatment plant. See Section 4.5.

i) Construction materials to be protected against corrosion due to high humidity.

j) Earthing and protection against lightning.

k) System manuals, plant function diagrams, electrical system, electrical circuit and instrument loop diagrams shall be provided before the plant is pre-commissioned.

l) Detailed and shop drawing for equipment, instrumentation and cable & cabling shall be provided.

2.3 Safety and Health Principles

Throughout the design, construction, commissioning, operation and maintenance stages of a project, the following safety principles shall apply:

2.3.1 General Safety

a) Malaysian Safety and Health legislations, standards and procedures under Occupational Safety and Health Act (OSHA) 1994, Factories and Machinery Act 1967 and etc. shall be followed.

b) Workforce, contractors, visitors and the public shall be safeguarded against hazards, risk of serious injury and disease.

c) Adequate training shall be made available for the use of all related equipment.

d) Appropriate training for end users to be identified and stipulated in construction and procurement documents.

e) Appropriate responsibilities to be assigned throughout each stage of a project.

f) Safety consciousness to be promoted by effective internal communication, signs and media.

g) Safety performance shall be easily audited during operation and maintenance.
h) All accidents or potential serious incidents to be reported and investigated.

i) Risk assessment to be undertaken at design of projects and selection stage of procurement.

j) Safety information and operating documents to be provided by suppliers.

k) Emergency contact list, showing telephone numbers of key personnel and emergency services during office hours and out of office hours, to be circulated to all parties involved in a project.

l) Plant (certain sized) should be provided with Emergency Response Plan (ERP)

m) All treatment plants, installation and construction sites, shall be provided with perimeter fencing adequate to protect the public from entry. All fencing shall be securely fixed and inspected.

n) All treatment plants, installations and construction sites shall have adequate warning signs at or near the perimeter.

o) Access to construction sites shall be controlled to prevent unauthorised access.

2.3.2 Structural Safety

a) Safe access to all working areas to be provided.

b) Routine requirement to enter confined spaces to be eliminated, where practicable.

c) Any confined space requiring routine person entry, which contains sewage, sludge or other foul water, to be ventilated.

d) Concrete slabs over wet wells, tanks and chambers shall have double steel reinforcing.

e) Lifting eyes and bolts for slabs to be stainless steel or any other durable and non-corrosive material.

f) Protection against falling (i.e. handrail, kick plate and toe plate) to be provided.

g) Within plants and installations, all wells, sumps, channels, chambers, tanks, etc. containing any liquid shall be covered, walled or railed.

h) Major hazards to be identified and posted on site.

i) Protection and counter measures against spillage of dangerous chemicals to be provided.
j) Permanent staircase shall be provided at inlet sumps, inlet wells, inlet chambers and dry-wells. Steps and riser shall follow UBBL Standard.

k) Adequate lifting facility shall be provided for heavy equipment, which requires maintenance work.

l) Blower room shall not share common wall and foundation with the control and genset room

### 2.3.3 Equipment and Electrical Safety

a) Electrical equipment and controls to be protected from unauthorised access.

b) Individual electrical drives to be capable of being isolated and locked off.

c) Electrical motors should be rated as continuous run.

d) Junction boxes for submersible pumps and float controls shall be above floor level outside the wet-well.

e) All electrical equipment in sumps, wet-wells, inlet channels, inlet chambers, sited below coping level to be explosion proof.

f) Lighting, appropriate to the needs of the end user, to be provided in working areas.

g) Registration of electrical / motorised equipment with Department of Safety and Health (DOSH).

h) Emergency stop button / isolator shall be provided for each equipment.

i) Power driven machinery to be guarded.

j) All equipment to be regularly checked and prominently marked accordingly