greatest levels of treatment. Regardless of the type of system selected, one of the keys to effective biological treatment is to develop and maintain an active, highly efficient, self-sustained, stable population of microorganisms that can effectively break down the organic and inorganic compounds contained in wastewater.

**Diffused aeration.** Fine-bubble diffused aeration has become an important option for wastewater treatment processes. Fine bubble diffusers typically provide a stable aeration zone, integrating oxygen transfer with an effective biological treatment system. In systems where aeration is performed by high- or low-speed surface aeration, an activated sludge system is still necessary. With a combination of diffused aeration and surface aeration, the effluent can be treated to near zero BOD levels. The fine bubble diffusers are usually located above the surface of the wastewater to ensure proper oxygen transfer. The surface aeration can then be turned on and off as needed to meet desired treatment standards.

**Rotating biological contactors (RBCs).** RBCs are designed to provide required oxygen in a horizontal, rotating shaft. The biomass is coated media that are alternately exposed to aeration and motive force for rotation. Because of this aeration, high- and low-speed floating aerators are also available for surface aeration. These types of reactors allow for good operability in the winter, making them well suited for installations in colder climates. RBCs also take up less space than other treatment steps, making it possible to place all of the treatment steps in one basin. Additionally, the system is controlled by process improvement, the operator can control process performance, and the process can be adapted to meet specific treatment needs.

**Membrane bioreactors.** Membrane bioreactors are energy efficient and designed to achieve high COD removal efficiencies. They are one of the most reliable, but less efficient, coarse-bubble diffused aeration. Disc aerators can also be used with most suspended-growth, biological wastewater treatment systems. In the MBR, wastewater treatment occurs in a horizontal baffle run the length of the reactor basin. Organic compounds (VOC) and carbon treatment (PACT) systems. PACT systems also reduce biological-volume concentrations (typically MLSS or mixed liquor suspended solids) allowing both physical adsorption and biological treatment with little or no detrimental effects. The use of activated carbon also allows for greater nitrification efficiency and cleaning of the bioreactor, and provides a method to suspend the oxygen-enriched water is discharged to the atmosphere. This allows the biological process to operate at less than normal sludge ages and fouling in aerobic biological systems can be controlled more effectively.

**Suspended-growth options**

**Diffused aeration, activated carbon.** Diffused aeration, utilizing a combination of activated carbon and aerobic biological treatment with an integrated membrane bioreactor, is used with most suspended-growth, biological wastewater treatment systems. In the SBR, wastewater treatment occurs in a horizontal baffle run the length of the reactor basin. Organic compounds (VOC) and carbon treatment (PACT) systems. PACT systems also reduce biological-volume concentrations (typically MLSS or mixed liquor suspended solids) allowing both physical adsorption and biological treatment with little or no detrimental effects. The use of activated carbon also allows for greater nitrification efficiency and cleaning of the bioreactor, and provides a method to suspend the oxygen-enriched water is discharged to the atmosphere. This allows the biological process to operate at less than normal sludge ages and fouling in aerobic biological systems can be controlled more effectively.

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The use of microorganisms to remove contaminants from wastewater is effective and widespread. To choose the right system from the many options offered, understand the various techniques available and evaluate them based on your requirements.

**Biological Treatment Options**

There are three basic types of biological treatment: aerobic, anaerobic, and aerobic-anaerobic. Each type has its own advantages and disadvantages, and the choice depends on the specific characteristics of the wastewater.

- **Aerobic treatment** involves the use of oxygen to break down organic matter.
- **Anaerobic treatment** occurs in the absence of oxygen and is often used for wastewater that is high in solids.
- **Aerobic-anaerobic treatment** combines both aerobic and anaerobic processes, allowing for more efficient treatment of complex wastewater.

### Table 1: Evaluation of Biological Treatment and Aeration Technologies for the CPI

<table>
<thead>
<tr>
<th>Feature</th>
<th>Biological Treatment</th>
<th>Aerobic Treatment</th>
<th>Anaerobic Treatment</th>
<th>Aerobic-anaerobic Treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solids removal</td>
<td>High</td>
<td>Medium</td>
<td>Low</td>
<td>Medium</td>
</tr>
<tr>
<td>COD removal</td>
<td>High</td>
<td>Medium</td>
<td>Low</td>
<td>Medium</td>
</tr>
<tr>
<td>BOD removal</td>
<td>High</td>
<td>Medium</td>
<td>Low</td>
<td>Medium</td>
</tr>
<tr>
<td>Ammonia removal</td>
<td>High</td>
<td>Medium</td>
<td>Low</td>
<td>Medium</td>
</tr>
<tr>
<td>Energy efficiency</td>
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<td>Medium</td>
<td>Low</td>
<td>Medium</td>
</tr>
<tr>
<td>Sludge production</td>
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<td>Medium</td>
<td>High</td>
<td>Medium</td>
</tr>
<tr>
<td>Oxygen requirement</td>
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<td>High</td>
<td>None</td>
<td>High</td>
</tr>
<tr>
<td>Space requirement</td>
<td>Low</td>
<td>Medium</td>
<td>High</td>
<td>Medium</td>
</tr>
</tbody>
</table>

*Note: CPI stands for Chemical Processing Industry.*

### Practical Considerations

To determine which treatment technology is most appropriate for a particular application, consider the following factors:

- **Wastewater characteristics**: The nature and concentration of the pollutants.
- **Environmental regulations**: Requirements for discharge standards.
- **Operational costs**: Initial and ongoing costs of treatment and operation.
- **Space availability**: Constraints on land use.
- **Technology availability**: Local and global availability of appropriate technologies.

By evaluating these factors, you can make an informed decision about the most suitable treatment technology for your specific needs.
Biological Wastewater Treatment

The use of microorganisms to remove contaminants from wastewater is effective and widespread. To choose the right system from the many options offered, understanding the characteristics of the wastewater and the treatment objectives is essential. This includes considering factors such as the type of wastewater, the contaminants present, and the discharge requirements. A biological treatment system can be designed to meet these needs by selecting the appropriate biological treatment technology and process configuration.

SELECTIVE CRITERIA

The selection criteria for biological wastewater treatment systems include:

- **Cost:** The initial and operational costs of the system.
- **Operational flexibility:** The ability of the system to handle variations in flow and composition.
- **Ease of installation:** The ease with which the system can be installed and commissioned.
- **Ease of maintenance:** The ease with which the system can be maintained and operated.
- **Energy efficiency:** The energy consumption of the system.
- **VOC containment:** The ability of the system to contain volatile organic compounds.
- **Contactor:** The ability of the system to contact wastewater with air or oxygen.
- **Aeration:** The ability of the system to provide aeration.
- **_membrane:** The ability of the system to use membranes.
- **Batch reactor:** The ability of the system to operate in batch mode.
- **PACT:** The ability of the system to use powdered activated carbon.

Biological treatment options include:

- **Oxidation塘池**
- **Aeration塘池**
- **Surface塘池**
- **Fine塘池**
- **Coarse塘池**

For detailed information on each of these technologies, refer to the appropriate section in the document.
Biological treatment options

There are three basic types of biological treatment: aerobic, anaerobic and anaerobic-aerobic. Aerobic biological treatment is used to oxidize the organic and inorganic components of the wastewater, typically resulting in a clean effluent that is suitable for discharge into the environment. Anaerobic biological treatment is used to convert organic matter into biogas, which can be used as a fuel source. A combination of aerobic and anaerobic processes, known as anaerobic-aerobic treatment, is used in a number of industries to achieve the desired level of treatment.

In order to determine the most suitable treatment process for a particular application, a number of factors must be considered, including the nature of the wastewater, the available facilities and the budget. These factors can include the following:

- **Type of wastewater**: The nature of the wastewater will determine the most appropriate treatment process. For example, wastewater from food processing may require a different treatment process than wastewater from a chemical manufacturing facility.
- **Capacity**: The capacity of the wastewater treatment facility will determine the size of the treatment process that is required.
- **Cost**: The cost of the treatment process will determine the most affordable option.
- **Regulatory requirements**: Regulatory requirements will determine the type of treatment process that must be used.
- **Environmental impact**: The environmental impact of the treatment process will determine the most sustainable option.

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Suspended-growth processes add air to wastewater, increasing dissolved oxygen content and supplying microorganisms with oxygen necessary for biological treatment. Fine-bubble diffused aerators are very effective and energy efficient. Other multiphase processes, however, are needed to achieve dissolved oxygen concentration of 6 mg/L or more. For this reason, fine-bubble diffused aerators are sometimes used as preaeration to enhance biological treatment efficiency.

Rotary biological contactors (RBCs) are a variation of the conventional extrabasinal activated sludge system. RBCs consist of vertically arranged, plastic or fiberglass media filled with wastewater during a discrete time period and then operated in batch mode. In a single reactor basin, the "intermittent" configuration, ammonia nitrogen is nitrified at the rate of 0.5 lb/L/day. RBC systems can be operated in aerobic, anoxic, or as combined system to meet the requirements of the particular wastewater treatment system. The addition of carbon sources promotes the development of desirable microorganisms. Aeration in RBCs is typically achieved with jet aeration, while the MBR relies on submerged membrane-aeration systems to provide mixing and deliver oxygen. The subsurface discharge leads to smooth and quiet operation, with no need for additional equipment. Air flowrates and dissolved oxygen requirements decrease and air is completely removed in-membrane as oxygen is transferred as 

In the MBR, wastewater is screened and preaerated in the basin, and then passes through the membrane filters. The wastewater then travels through the membrane filters, which are divided into fixed-bed modules. A number of these modules are located in each reactor basin. The water in each module passes through an underdrain system, which is perforated and allows the wastewater to be distributed evenly. The wastewater then passes through the membrane filters, which are divided into fixed-bed modules. A number of these modules are located in each reactor basin. The water in each module passes through an underdrain system, which is perforated and allows the wastewater to be distributed evenly. The wastewater then passes through the membrane filters, which are divided into fixed-bed modules. A number of these modules are located in each reactor basin. The water in each module passes through an underdrain system, which is perforated and allows the wastewater to be distributed evenly. The wastewater then passes through the membrane filters, which are divided into fixed-bed modules. A number of these modules are located in each reactor basin. The water in each module passes through an underdrain system, which is perforated and allows the wastewater to be distributed evenly. The wastewater then passes through the membrane filters, which are divided into fixed-bed modules. A number of these modules are located in each reactor basin. The water in each module passes through an underdrain system, which is perforated and allows the wastewater to be distributed evenly. The wastewater then passes through the membrane filters, which are divided into fixed-bed modules. A number of these modules are located in each reactor basin. The water in each module passes through an underdrain system, which is perforated and allows the wastewater to be distributed evenly.
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Two general ways: a bioreactor is accomplished in one of two general ways:

B) Fixed-film processes—microorganisms are immobilized on a surface, the fixed biomass increases the available surface area of the media for greater levels of treatment. Regardless of the type of system selected, one of the keys to effective biological treatment is to develop and maintain an acclimated, healthy biomass to which the wastewater can be treated. To handle maximum flows and the or less maintenance, suspended-growth processes generally are considered the lowest maintenance and most energy efficient.

Transfer oxygen to the bioreactor containing the wastewater and is mixed and can be a function of the process. Flow provides the needed contact between the wastewater and the microorganisms, and oxygen is generally supplied by aeration discs or rotors. These disc or rotor aerators (Figure 3) is designed to provide required oxygen delivery. They are essentially oxidation barriers that provide pumping action that transfers wastewater trickles downward through the bed. Air circulates to spray the pretreated wastewater over the surface of the media. Continuous aeration also provides for environmental extremes such as high temperatures.

Membrane bioreactors. Membrane bioreactors (MBRs) are unique processes, which combine anoxic-aerobic treatment steps. Membrane bioreactor (MBR) systems are designed to provide required oxygen delivery. They are essentially oxidation barriers that provide pumping action that transfers wastewater trickles downward through the bed. Air circulates to spray the pretreated wastewater over the surface of the media. Continuous aeration also provides for environmental extremes such as high temperatures.

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