Micro-Algae Growth Technology Systems

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Micro-algae growth technology systems have been researched & developed since several decades in various designs for more efficient productions.

All of these micro-algae production designs have advantages and disadvantages, which should be considered.

This paper examines & compares the systems, which are still being used depending on land area needed, productivity values, advantages, disadvantages, tools needed, costs.
Micro-algae Growth Technology Systems
- Open Pond Systems
- Closed Pond Systems
- Tubular Systems
- Plastic Bag Systems
- Well Systems (Especially for chlorophyll reduced micro-algae)
- Pyramid Photobioreactor Systems
Open Pond Systems’ General Properties

- Round or raceway built
- Mild mixing and waves
- Paddlewheel, waterjet or air pump systems could be used
- Optimal open pond dimensions are: 50 m. X 5 m. X 0.4 m. with 100 tons of water media
- Maximum spirulina productivity: 0.35 g/lt
- **100 tons capacity pond = 35 kg/day**
- 250 m² area is required for 100 tons of water media
- These dimensions are used due to contamination risks, circulation & mixing problems
- These dimensions are useful in case of culture & medium & various problems, giving the possibility to divide these risks.
- Larger volume ponds have higher risks.
Materials Needed For Paddlewheel Drived Open Pond Systems
- Paddlewheel
- Isolation material (white colored, minimum 20 years resistant to chemicals, water proof)
- Starter chemicals
- Culture
- Hand-held conductivity-meter
- Hand-held pH-meter
- Hand-held algae-counter
- Algae filter (optional)
- Solar panels and/or wind mill (optional)
Paddlewheel Drived Open Pond System
Materials Needed For Waterjet Open Pond Systems

- Waterjet circulation pipe and mechanism
- Isolation material (white colored, minimum 20 years resistant to chemicals, water proof)
- Starter chemicals
- Culture
- Hand-held conductivity-meter
- Hand-held pH-meter
- Hand-held algae-counter
- Algae filter (optional)
- Solar panels and/or wind mill (optional)
Waterjet Open Pond System

Waterjet for micro-algae
Materials Needed For Air Pump Open Pond Systems

- Oil-free air pump
- Air distribution pipes and mechanisms
- Isolation material (white colored, minimum 20 years resistant to chemicals, water proof)
- Starter chemicals
- Culture
- Hand-held conductivity-meter
- Hand-held pH-meter
- Hand-held algae-counter
- Algae filter (optional)
- Solar panels and/or wind mill (optional)
Air Pump Open Pond System

Air Pump

Air Distributer
Closed Pond Systems’ General Properties

- Round or raceway built
- Mild mixing and waves
- Paddlewheel, waterjet or air pump systems could be used
- Optimal open pond dimensions are: 50 m. × 5 m. × 0.4 m. with 100 tons of water media
- Maximum spirulina productivity: 0.35 g/lt

**100 tons capacity pond = 35 kg/day**

- 250 m² area is required for 100 tons of water media
- These dimensions are used due to contamination risks, circulation & mixing problems
- These dimensions are useful in case of culture & medium & various problems, dividing these risks.
- Larger volume ponds have higher risks.
Materials Needed For Closed Pond Systems

- Plexi-glass and metal construction materials
- Oil-free air pump or waterjet or paddlewheel
- Air or waterjet distribution/circulation pipes and mechanisms (not needed for paddlewheel)
- Isolation material (white colored, minimum 20 years resistant to chemicals, water proof)
- Starter chemicals
- Culture
- Hand-held conductivity-meter
- Hand-held pH-meter
- Hand-held algae-counter
- Algae filter (optional)
- Solar panels and/or wind mill (optional)
Closed Pond System

Plexi-glass and metal construction

Soil

Pool
Tubular Systems’ General Properties

- Vertical, parallel lined, acrylic tubes, max. 30 cm radius due to light penetration problems
- Motor-pump mixing
- Maximum spirulina productivity: 0.8 g/lt
- **100 tons capacity tubular system = 80 kg/day**
- 1200 m2 area required for 100 tons of water media
Materials Used For Tubular Systems

Acrylic tubes
Motor-pump
Cooling unit
Harvesting filters
Medium control units
Computerized control panel
Starter chemicals
Culture
Conductivity-meter
pH-meter
Algae-counter
Algae filter (optional)
Solar panels and/or wind mill (optional)
Plexi-glass and metal construction materials (optional, needed for covered systems)
Plastic Bag Systems’ General Properties

- Vertical, parallel lined, hanging plastic bags
- Circulation-pump is used
- Maximum spirulina productivity: 0.6 g/lt
- **100 tons capacity tubular system = 60 kg/day**
- 1200 m2 area required for 100 tons of water media
Materials Needed For Plastic Bag Systems

- Plastic Bags
- Circulation-pump
- Thermal tubes
- Cooling unit
- Harvesting filters
- Medium control units
- Computerized control panel
- Starter chemicals
- Culture
- Conductivity-meter
- pH-meter
- Algae-counter
- Algae filter (optional)
- Solar panels and/or wind mill (optional)
- Plexi-glass and metal construction materials
Plastic Bag System
Plastic Bag System
Well Systems’ General Properties (Especially for chlorophyll reduced micro-algae)

- Underground constructed well system requiring less area and light
- Also suitable for landscapes such as deserts
- Air-pump mixing
- Optimal well dimensions are: 5 m. X 5 m. X 4 m. with 100 tons of water media
- 4 m. depth could be used due to more light penetration for chlorophyll reduced microalgae
- Maximum spirulina productivity: 0.9 g/lt
- **100 tons capacity well system = 90 kg/day**
- 25 m² area required for 100 tons of water media
Materials Needed For Well Systems

- Underground well
- Metal tank
- Isolation material (white colored, minimum 20 years resistant to chemicals, water proof)
- Air-pump
- Starter chemicals
- Culture
- Hand-held conductivity-meter
- Hand-held pH-meter
- Hand-held algae-counter
- Algae filter (optional)
- Solar panels and/or wind mill (optional)
- Circulation-pump

Normal Spirulina Culture
Chlorophyll Reduced Spirulina Culture
Well System
Pyramid Photobioreactor Systems’ General Properties
-Fully automated-computerized, ultra-durable, latest technology photobioreactor system
-Airlift mixing is used
-Maximum spirulina productivity: 1.45 g/Lt
-100 tons capacity pond = 145 kg/day
-60 m2 area is required for 100 tons of water media
Embedded Pyramid Photobioreactor System Parts

- Pyramid body
- Backlights (Led/Floresant)
- Control circuit
- Control panel
- Circulation pump
- Air pump
- Harvest pump
- 4 ways gas input
- O2, CO2, Nx valve
- Nutrients input
- Sterilization tank (UV)
- Circulation tank
- Algae filter
- Laser algae counter
- Starter chemicals
- Culture
- pH-meter
- CO2 meter
- Temp-meter
- Circulation-meter
- Light sensor
- Conductivity sensor
- Heater
- Dehumiditer
- Control software
- Connectors & hoses
- Cooler
1-Pyramid Body
2-Black Box
3-Medium Pump
4-Twilight Zone Tank
5-Mid-Illumunating
6-UV Lamps
7-Cooling Unit
8-Feeding Unit
9-Control Panel
10-Harvest Filters
# Comparision Chart of Most Popular PBRs & Ponds

<table>
<thead>
<tr>
<th></th>
<th>Open Pond</th>
<th>Closed Pond</th>
<th>Tubular Systems</th>
<th>Plastic Bag Systems</th>
<th>Well System</th>
<th>Pyramid Photobioreactor System</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Water Media (tons)</strong></td>
<td>250</td>
<td>250</td>
<td>1200</td>
<td>1200</td>
<td>25</td>
<td>60</td>
</tr>
<tr>
<td><strong>Area Requirement (m²)</strong></td>
<td>100</td>
<td>25</td>
<td>1200</td>
<td>1200</td>
<td>25</td>
<td>60</td>
</tr>
<tr>
<td><strong>Daily Production (kg dry wt.)</strong></td>
<td>1200</td>
<td>60</td>
<td>90</td>
<td>145</td>
<td>250</td>
<td>90</td>
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<tr>
<td><strong>Areal Productivity (kg/m²/day)</strong></td>
<td>0,066</td>
<td>0,05</td>
<td>3,6</td>
<td>2,416</td>
<td>3,6</td>
<td>2,416</td>
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<tr>
<td><strong>Contamination Risk</strong></td>
<td>+++</td>
<td>+++</td>
<td>++</td>
<td>++</td>
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<tr>
<td><strong>Evaporation Losses</strong></td>
<td>+++</td>
<td>+++</td>
<td>++</td>
<td>+++</td>
<td>+++</td>
<td>+</td>
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<tr>
<td><strong>Energy Requirement</strong></td>
<td>+++</td>
<td>+++</td>
<td>+++</td>
<td>+++</td>
<td>++</td>
<td>+</td>
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<tr>
<td><strong>Overheating Potential</strong></td>
<td>+++</td>
<td>+++</td>
<td>+++</td>
<td>+++</td>
<td>++</td>
<td>+</td>
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<tr>
<td><strong>Staff Requirement</strong></td>
<td>+++</td>
<td>+++</td>
<td>++</td>
<td>++</td>
<td>++</td>
<td>+</td>
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<tr>
<td><strong>Maintance Costs</strong></td>
<td>+++</td>
<td>+++</td>
<td>+++</td>
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<tr>
<td><strong>Periodic Maintance Requirement</strong></td>
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<td>++</td>
<td>+++</td>
<td>+++</td>
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<tr>
<td><strong>Irreversible System Faults</strong></td>
<td>+++</td>
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<td><strong>Microbiological Safety</strong></td>
<td>+</td>
<td>++</td>
<td>+++</td>
<td>+++</td>
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<td>+++</td>
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<tr>
<td><strong>Air Cleaning Capacity</strong></td>
<td>+</td>
<td>+</td>
<td>+++</td>
<td>++</td>
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<td>+++</td>
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<tr>
<td><strong>Waste Gas Use Capacity</strong></td>
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<td>+++</td>
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<td>+++</td>
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<tr>
<td><strong>Productivity Stability (Season, temp, sunlight, etc.)</strong></td>
<td>+</td>
<td>++</td>
<td>+++</td>
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