



## Biofloc Carbon Source Management and Sludge Control Techniques for Stable Production of *Litopenaeus vannamei*

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Biofloc technology (BFT) has emerged as a sustainable and intensive shrimp farming system that enhances water quality, reduces feed cost, and improves biosecurity. In *Litopenaeus vannamei* culture, proper carbon source management is essential for maintaining optimal carbon:nitrogen (C:N) balance, promoting heterotrophic microbial growth, and controlling toxic nitrogen compounds. However, excessive organic accumulation leads to sludge formation, oxygen depletion, and system instability. This technical article discusses carbon source selection, C:N ratio management, microbial control, and sludge mitigation strategies for stable and productive biofloc-based shrimp farming systems.

### Introduction

Biofloc technology is a zero- or limited-water exchange aquaculture system that relies on microbial communities to recycle nitrogenous waste into microbial biomass. In *Litopenaeus vannamei* farming, BFT improves feed utilization efficiency, enhances immunity, and reduces environmental discharge. The success of biofloc systems depends primarily on maintaining a stable carbon:nitrogen ratio, typically ranging from 12:1 to 20:1 depending on system intensity. Proper carbon supplementation promotes heterotrophic bacterial growth, which assimilates ammonia and converts it into microbial protein available as natural food for shrimp. However, improper carbon dosing or poor sludge management can destabilize the system.

### Carbon Source Management in Biofloc Systems

#### Role of Carbon Sources

Carbon sources support heterotrophic bacterial growth, which assimilates inorganic nitrogen (ammonia, nitrite) into microbial biomass. This reduces toxicity and enhances natural food availability.

#### Common Carbon Sources Used

- Molasses
- Rice bran
- Wheat flour
- Tapioca starch
- Sugarcane by-products
- Commercial carbon blends

Molasses is widely used due to its rapid solubility and cost-effectiveness.

#### Carbon:Nitrogen (C:N) Ratio Management

Maintaining the correct C:N ratio is critical for system stability.

- **Initial phase:** 15:1 to 20:1 (floc development stage)
- **Grow-out phase:** 12:1 to 15:1 (stabilized system)

Carbon dosing is calculated based on feed protein input and nitrogen release from uneaten feed and excretion. Over-carbonation leads to oxygen depletion, while under-carbonation results in ammonia accumulation.

### **Carbon Dosing Strategy**

- Gradual carbon addition rather than bulk dosing
- Split applications (2–4 times/day)
- Adjustment based on ammonia and floc volume observations
- Reduction during low feeding or molting phases

### **Microbial Floc Development and Stability**

Stable biofloc formation requires continuous aeration and balanced nutrient input. Heterotrophic bacteria dominate under high C:N conditions, forming aggregates with organic particles and algae.

Key indicators of stable biofloc:

- Brownish water color
- Moderate floc volume (10–20 mL/L in Imhoff cone)
- Low ammonia and nitrite levels
- Active shrimp feeding on suspended flocs

Excess floc (>30–40 mL/L) indicates overload and risk of oxygen depletion.

### **Sludge Formation and Its Impacts**

Sludge accumulation occurs due to uneaten feed, feces, dead microbial biomass, and sedimented organic matter. In biofloc systems, uncontrolled sludge buildup can lead to:

- Anaerobic conditions at pond bottom
- Hydrogen sulfide (H<sub>2</sub>S) generation
- Increased pathogenic bacterial load
- Reduced dissolved oxygen availability
- Poor shrimp growth and survival

Sludge management is therefore essential for long-term system stability.

### **Sludge Control Techniques in Biofloc Systems**

#### **Aeration Management**

Strong and continuous aeration is the primary method for preventing sludge deposition. Aerators should be placed to create circular water movement and keep particles in suspension.

- Minimum DO: >5 mg/L
- Continuous bottom circulation required

#### **Mechanical Sludge Removal**

- Use of central sludge collection points in lined ponds
- Siphoning or pumping of settled waste
- Periodic bottom cleaning in nursery tanks

#### **Microbial Sludge Degradation**

- Application of probiotic *Bacillus* spp.
- Enzyme-based sludge digesters
- Organic matter decomposition enhancement

These approaches accelerate breakdown of organic waste into harmless by-products.

#### **Biofloc Volume Control**

Floc volume should be regularly monitored using Imhoff cones.

- Optimal range: 10–20 mL/L
- If >25–30 mL/L: reduce carbon input and increase sludge removal
- If <10 mL/L: increase carbon supplementation

#### **Water Exchange and Dilution (Limited Use)**

Although biofloc systems are designed for minimal exchange, emergency partial water exchange may be required during:

- Toxic ammonia spikes
- Excess sludge accumulation
- System crash conditions

### **Integrated Carbon–Sludge–Oxygen Balance**

Carbon management, sludge accumulation, and oxygen demand are tightly interlinked. Excess carbon increases microbial respiration, which raises oxygen demand and accelerates sludge formation. Therefore, maintaining balance is essential:

- Balanced carbon input → stable floc + low ammonia
- Excess carbon → oxygen depletion + sludge buildup
- Low carbon → ammonia accumulation + toxic stress

Proper aeration design is therefore as important as carbon dosing strategy.

### **Discussion**

Biofloc-based *Litopenaeus vannamei* farming offers high productivity but requires precise system management. Carbon source mismanagement is one of the most common causes of system instability. Similarly, sludge accumulation is often underestimated but has severe long-term effects on pond health. An integrated approach combining controlled carbon dosing, continuous aeration, microbial management, and sludge removal ensures system stability. Future improvements may include automated carbon dosing systems and sensor-based floc monitoring to enhance precision aquaculture practices.

### **Conclusion**

Stable production of *Litopenaeus vannamei* in biofloc systems depends on precise carbon source management and effective sludge control techniques. Maintaining optimal C:N ratios, ensuring adequate aeration, and preventing organic accumulation are critical for system stability. Proper implementation of these strategies improves shrimp growth, enhances feed utilization, and supports sustainable intensification of aquaculture systems.