

# Using Dissolved Air Flotation Technology for Algae Removal in Aeration Lagoons

A study based on performance data gathered during a 6-week DAF pilot test



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# Project Brief

During the warm summer months, a two-million gallon per day wastewater treatment facility experiences extreme algae growth in two aeration lagoons. This overgrowth results in elevated Suspended Solids (TSS) concentration in the effluent, which is of major concern to the facility as all discharge flows directly into a local waterway.

To mitigate this and several other performance related problems, FRC suggested piloting a Dissolved Air Flotation (DAF) system. The following report describes the pilot study methodology and outcomes.

## Pilot Study Objectives

- Remove algae and reduce TSS to permissible discharge value
- Reduce Phosphorus (TP) to permissible limit
- Reduce Carbonaceous Biochemical Oxygen Demand (CBOD) to permissible discharge value
- Demonstrate stable and reliable performance of the DAF process
- Establish design and operating parameters for a full-scale system

Pilot studies serve as a critical bridge between theoretical design and practical application, delivering real-world data that validates assumptions, identifies unforeseen challenges, and enhances decision-making. When conventional design theory proves insufficient, pilot studies provide empirical insights that drive innovation, optimize processes, and ensure more effective implementation.

# Algae Blooms & Treatment Lagoons

Wastewater treatment lagoons depend on bacteria to break down organic contaminants such as fats, sugars, phosphates, and nitrogen. However, disruptions to bacterial populations can destabilize the entire system, leading to uncontrolled algae blooms and poor effluent quality. Maintaining the right bacterial balance is crucial for effective wastewater treatment.

The microbes in wastewater lagoons are naturally occurring and adapted to local environmental conditions. Their primary function is to decompose organic matter into biological solids that can be filtered out. Oxygen levels and nutrient concentrations—primarily nitrogen (N) and phosphorus (P)—directly influence bacterial efficiency. Excessive N and P can lead to bacterial overgrowth and sludge accumulation, inhibiting proper lagoon function and triggering cyanobacterial (blue-green algae) blooms.

Algae blooms are most common from early spring to late autumn when warm temperatures and agricultural runoff rich in fertilizers enter the system. These blooms introduce large amounts of decaying organic material, creating anoxic conditions that suppress beneficial bacterial growth. A lack of oxygen leads to septic conditions, increased suspended solids, and higher levels of total suspended solids (TSS) and total phosphorus (TP) in discharged effluent. Additionally, decomposing algae generate unpleasant odors that can affect nearby communities.



Algae grows in excess when water is stagnant, insufficiently oxygenated, and contains high levels of nitrogen and phosphorus

To prevent these issues before they escalate, a wastewater treatment facility in this study explored proactive measures. Having previously used Dissolved Air Flotation (DAF) systems for post-lagoon solids and nutrient removal, they initiated a pilot study to assess its effectiveness in maintaining lagoon balance and preventing harmful algae blooms.

# How DAF Works

A Dissolved Air Flotation (DAF) system is a water treatment technology used to remove suspended solids, oils, grease, and other contaminants. Here's how it works in five steps:

## 1. Pre-Treatment and Chemical Addition

- Wastewater is first pre-treated to remove large debris or coarse particles.
- Chemicals, such as coagulants and flocculants, are added to the water. These chemicals help aggregate fine particles and suspended solids into larger clumps (flocs), making them easier to separate.

## 2. Air Saturation in Water

- In a pressurization tank, air is dissolved into water under high pressure. This creates a solution saturated with microbubbles.
- The saturated water is then released into the DAF unit, where the pressure drops, causing the air to form tiny bubbles.

## 3. Bubble Attachment to Particles

- The microbubbles attach to the suspended solids and flocs, reducing their density.
- This attachment process causes the particles to rise to the surface of the water.

## 4. Flotation and Skimming

- As the particles float to the surface, they form a sludge layer.
- A mechanical skimmer continuously removes this floating sludge and directs it to a sludge collection system for further processing or disposal.

## 5. Clear Water Collection

- The treated water, now free of most suspended solids and contaminants, flows to the bottom of the tank and is discharged or sent for further treatment if necessary.
- Some of the treated water may be recirculated back into the pressurization tank for continuous operation.

This process ensures efficient removal of contaminants, making DAF systems ideal for industries like food processing, oil refineries, and wastewater treatment plants.

# Design Parameters

Municipal wastewater treatment facilities are subject to the jurisdiction of city, state, and federal effluent water quality regulations, which vary by geographic region and point of discharge. The permitted limits for the wastewater treatment facility in this pilot study are given as follows:

Constituent	PERMITTED LIMITS	
	Weekly Average	Monthly Average
TP	1 mg/L	1 mg/L
CBOD	37.5 mg/L	25 mg/L
TSS	135 mg/L	90 mg/L

The wastewater treatment system design parameters for the facility are based on historical wastewater analyses provided to FRC by the client.

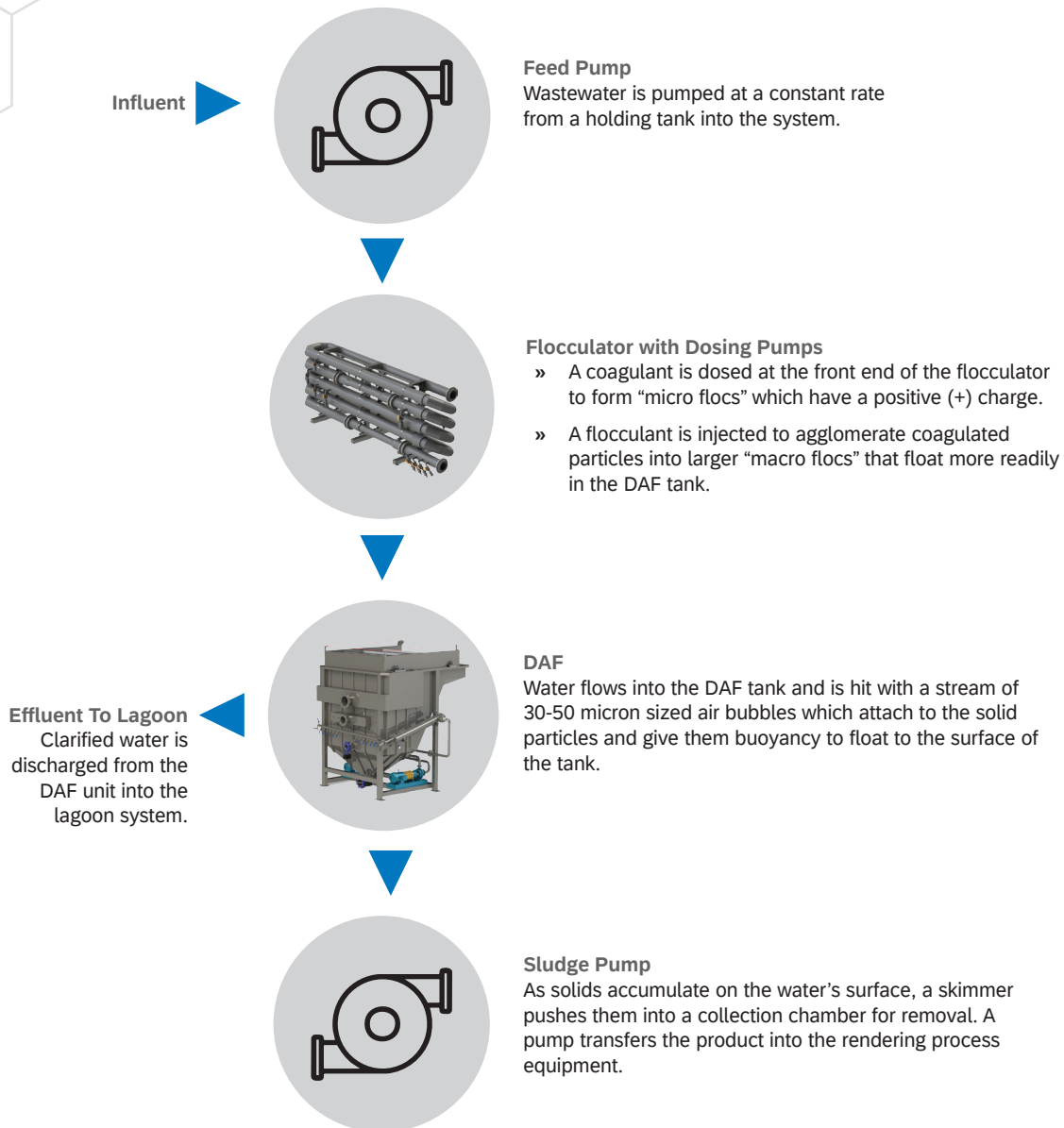
WASTEWATER CHARACTERISTICS	
Constituent	Value
TP	1.07 mg/L
CBOD	23.97 mg/L
TSS	31.92 mg/L

## DAF Design Parameters

The DAF system used for this pilot study is a rectangular vessel constructed of stainless steel that is fitted with a flight-and-chain skimmer assembly, recycle pump, air dissolving tube, bottom auger, and instruments for measuring flow rate, water level, and pH.

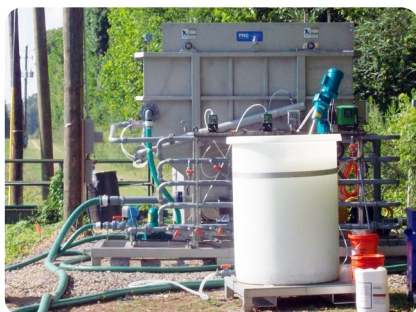
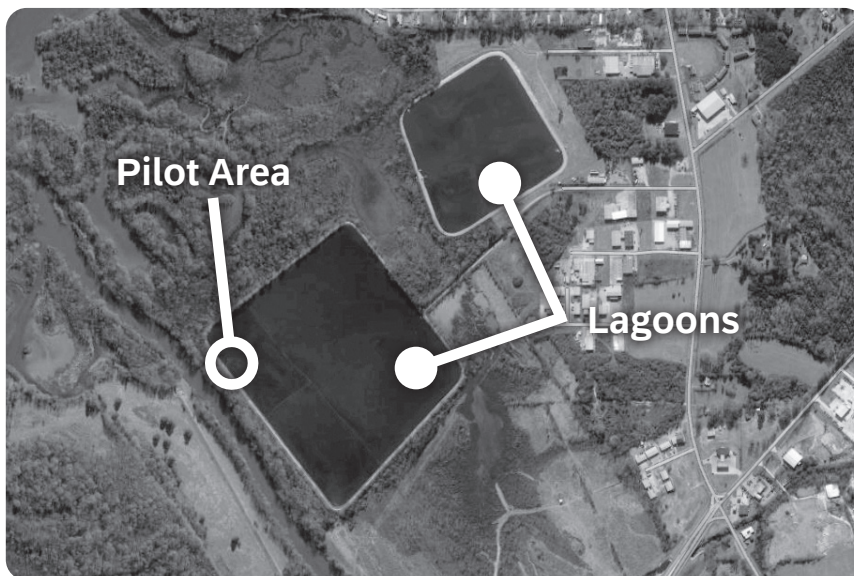
Constituent	Weekly Average
Air Flow	1.4 lpm
DAF Feed Flow	20 gpm max.
DAF Recycle Flow	8 gpm max.
Free Surface Area	14 sq. ft.

# Equipment Implementation



# Field Layout

The DAF system was placed adjacent to the lagoon and connected to a power source. A 3" flexible hose was used to transfer water from the lagoon into the process equipment. After treatment, clarified water flowed by gravity into the lagoon, while separated sludge was pumped into a holding tank for disposal.



**A tank and mixer assembly prepare chemicals that are used to aid in solids separation.**



**Chemical feed pumps dose coagulant and flocculant into the flocculator.**



**Treated samples are drawn for analysis.**

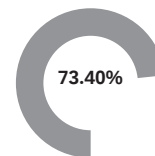
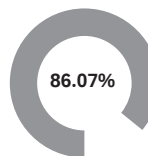
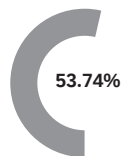
# Lab Analysis

The DAF system operated next to the lagoon for six weeks. Two auto-samplers - one operator owned, the other performed through independent analysis - were used to collect water samples every hour from two locations. Wastewater analyses were performed at on and offsite laboratories.

## Owner's Analysis

	Total P (mg/L)		TSS (mg/L)		CBOD (mg/L)	
	Influent	Effluent	Influent	Effluent	Influent	Effluent
Week 1	1.24	1.27	15.00	5.50	24.53	13.15
Week 2	0.95	0.69	24.16	6.84	22.60	10.78
Week 3	1.14	0.84	33.84	4.00	19.64	6.49
Week 4	0.95	0.61	37.67	3.08	18.64	2.84
Week 5	1.00	0.19	37.00	2.33	27.77	2.04
Week 6	1.15	0.15	43.84	4.92	31.11	2.94
<b>Average</b>	<b>1.07</b>	<b>0.50</b>	<b>31.92</b>	<b>4.45</b>	<b>23.97</b>	<b>6.38</b>

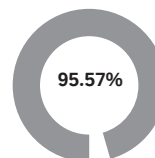
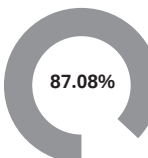
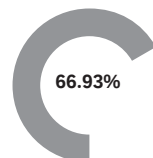
Percent  
Reduction



## Independent Analysis

	Total P (mg/L)		TSS (mg/L)		CBOD (mg/L)	
	Influent	Effluent	Influent	Effluent	Influent	Effluent
Week 1	0.73	0.34	15.50	6.00	25.48	1.75
Week 2	1.19	0.74	38.34	8.33	60.75	1.58
Week 3	1.48	0.59	38.00	2.50	39.88	1.48
Week 4	1.16	0.22	18.33	2.00	28.01	1.50
Week 5	1.46	0.26	33.66	1.50	25.21	2.03
Week 6	1.69	0.39	39.18	3.33	29.86	0.91
<b>Average</b>	<b>1.29</b>	<b>0.42</b>	<b>30.53</b>	<b>3.94</b>	<b>34.87</b>	<b>1.54</b>

Percent  
Reduction



# Process Calculations

Over the course of the pilot study, several liquid coagulants were applied to identify which would be most effective in precipitating phosphorus out of solution. Although both iron and aluminum-based formulations proved effective, one particular blend of polyaluminum chloride (PAC) provided the best results, consistently reducing phosphorus concentration to less than 1 mg/L in jar tests and in the DAF effluent.

## Polyaluminum Chloride Advantages

- PAC reacts faster than aluminum sulfate because of its polymeric structure which allows for higher coagulation efficiency
- Formed flocs are bigger, which means thicker, drier sludge
- It leaves lower quantities of residual aluminum in water
- It consumes less alkalinity than other coagulants, so pH correction is generally not necessary
- PAC remains efficient over large pH ranges

The pilot study provided the following design data for the full-scale DAF system:

## Hydraulic Surface Loading Rate

The volume of wastewater applied per square foot of effective separation area.

$$\frac{\text{DAF Flow Rate} + \text{DAF Recycle Flow Rate (gpm)}}{\text{DAF Effective Separation Area (sq.ft.)}} = \frac{20 \text{ gpm} + 8 \text{ gpm}}{14 \text{ sq. ft.}} = 2.00 \text{ gpm} / \text{sq. ft.}$$

## Solids Loading Rate

The weight of solids separated per square foot of free surface area.

\*For this application, solids loading ended up not being a critical design parameter, as the figure is well below an established value of 2.5 lb/sq.ft./hr

$$\frac{\text{Weight of TSS in Feed Flow to DAF (lb/hr)}}{\text{DAF Free Separation Area (sq.ft.)}} = \frac{1 \text{ lb/hr}}{14 \text{ sq. ft.}} = 0.07 \text{ lb} / \text{sq.ft.} / \text{hr}$$

## Air-to-Solids Ratio

The volume of air required to separate a given weight of solids.

$$\frac{\text{Pounds of Air at STP (lb/hr)}}{\text{Weight of TSS to be Separated (lb/hr)}} = \frac{0.094 \text{ lb/hr}}{1.001 \text{ lb/hr}} = 0.01$$

# Conclusion

Prior to the pilot study, the wastewater treatment lagoon was overgrown with algae and unable to sufficiently reduce TSS and phosphorus to meet permitted discharge limits. FRC engineers suggested using a Dissolved Air Flotation system to focus on algae removal. The DAF system ran with minimal operator intervention for six weeks while samples were collected and analyzed at on and off-site laboratories.

There is a notable difference in the lab analyses of the wastewater samples. This can be attributed to the calibration of sampling equipment and varied time-lapses between drawing and delivering samples for analysis. Despite the discrepancy between the two data sets, both show a marked improvement in effluent quality after treatment by the DAF system.

As expected, the DAF pilot system consistently achieved the desired TSS, TP, and CBOD removal rates to bring the facility within permitted discharge limits.

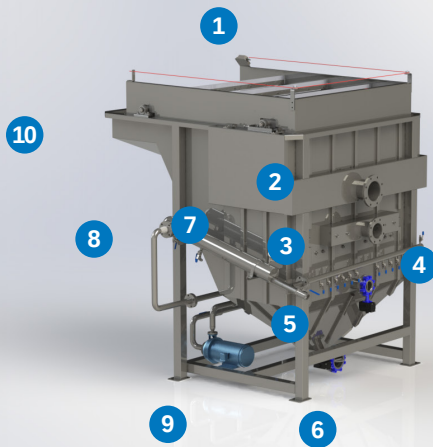
In conclusion, facilities facing surcharges or complete shutdown as a result of cyanobacteria blooms would be well advised to employ a Dissolved Air Flotation system to aid in algae removal.



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# PCL-Series High-Rate DAF

## PCL-Series DAF



- 1 Skimmer Flights
- 2 Effluent Flange
- 3 Influent Flange
- 4 Dissolved Air Dispersion Manifold
- 5 Sand Trap Outlet
- 6 Settled Sludge Outlet
- 7 Plate Pack (tank interior)
- 8 Air Dissolving Tube
- 9 ANSI Recycle Pump
- 10 Float Discharge

**The PCL-Series DAF delivers efficient, reliable, and compact wastewater treatment, with high performance, energy savings, and environmental sustainability.**

The FRC series of PCL Dissolved Air Flotation (DAF) units are high-built (tall) solid/liquid separators engineered for a variety of flow rates and applications. The PCL Series design utilizes a combination of cross flow plate pack technology and the sludge dewatering grid to generate sludge with high dry solids content.

This project utilized a PCL-Series Dissolved Air Flotation (DAF) system, a reliable solution for effectively removing suspended solids, oils, and grease from water. However, FRC Systems offers a diverse range of DAF systems tailored to accommodate varying flow rates and treatment needs.

Among these is the PWL-Series DAF system, designed to handle larger flow rates and provide high-efficiency water treatment for various applications. FRC's flexibility ensures a suitable system for every project requirement.



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