USING DISSOLVED AIR FLOTATION TECHNOLOGY FOR ALGAE REMOVAL IN AERATION LAGOONS

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

FRC SYSTEMS INTERNATIONAL
Trusted Wastewater Solutions™

TABLE OF CONTENTS

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
DELIVER REAL WORLD
DATA WHEN
DESIGN THEORY
DOESN'T CUT IT

UNDERSTANDING ALGAE

Wastewater treatment lagoons rely on bacteria to consume organic contaminants found in wastewater like fats, sugars, phosphates, and nitrogen. When their population is disturbed an entire lagoon system can be thrown off-kilter, resulting in uncontrollable algae blooms and poor effluent quality. The question is, how do you maintain the right balance of bacteria? First, some baseline information is in order.

The microbes normally found in wastewater lagoons are indigenous to the surrounding area. As such, they're accustomed to the local climate. The purpose of these organisms is to break down organic contaminants into biological solids that can be easily filtered from the wastewater. How well the bacteria function is largely dictated by the concentration of oxygen and nutrients (nitrogen-N and phosphorus-P) present in the lagoon. A significant concentration of N and P entering the wastewater can cause an overaccumulation of bacterial floc, or sludge layer, inhibiting the lagoon's ability to function. The light green color associated with this scenario is the result of a cyanobacterial bloom.

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

Algae blooms typically occur between early Spring and late Autumn when temperatures are high and agricultural runoff laden with fertilizers enters the wastewater system. These blooms produce excesssive concentrations of dead organic matter that cause anoxic conditions and limit the growth of healthy bacteria. Insufficient oxygen causes septic conditions and results in elevated levels of suspended solids, increasing the probability for out of compliance TSS and TP in discharged effluent. Finally, the bad odor that eminates from all the decomposing algae can be a major nuisance to nearby residents.

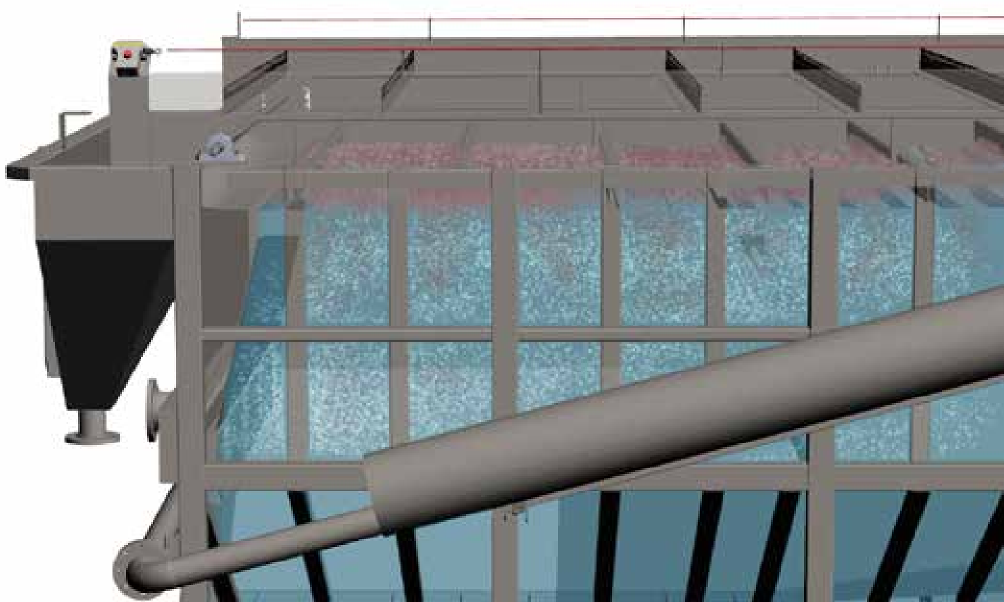
These are the very issues the wastewater treatment facility in this study wanted to prevent before a minor blip in performace became a major problem. Having successfully used DAF systems to aid in post-lagoon solids and nutrient removal, FRC suggested performing a pilot study.

HOW DAF WORKS

DAF systems operate on a simple principle: tiny bubbles bouy contaminants to the water's surface where they're skimmed for removal. This is how FRC's DAF unit does just that.

the MAGIC IS IN THE AIR

As wastewater is pumped into the flotation vessel, a sidestream of recycled water that is super-saturated with dissolved air enters the mix. Upon release at atmospheric pressure, millions of tiny bubbles indiscernable to the naked eye disperse and attach to contaminants in the waste stream. Gradually a sludge blanket accumulates on the water's surface, where it is skimmed for removal.



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:

PERMIT LIMITS

Constituent	Weekly Avg.	Monthly Avg.
TP	1 mg/L	1 mg/L
CBOD	37.5 mg/L	25 mg/L
TSS	135 mg/L	90 mg/L

WASTEWATER CHARACTERISTICS

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

Wastewater characteristics for the facility during periods of excess algae growth are shown in the table to the left.

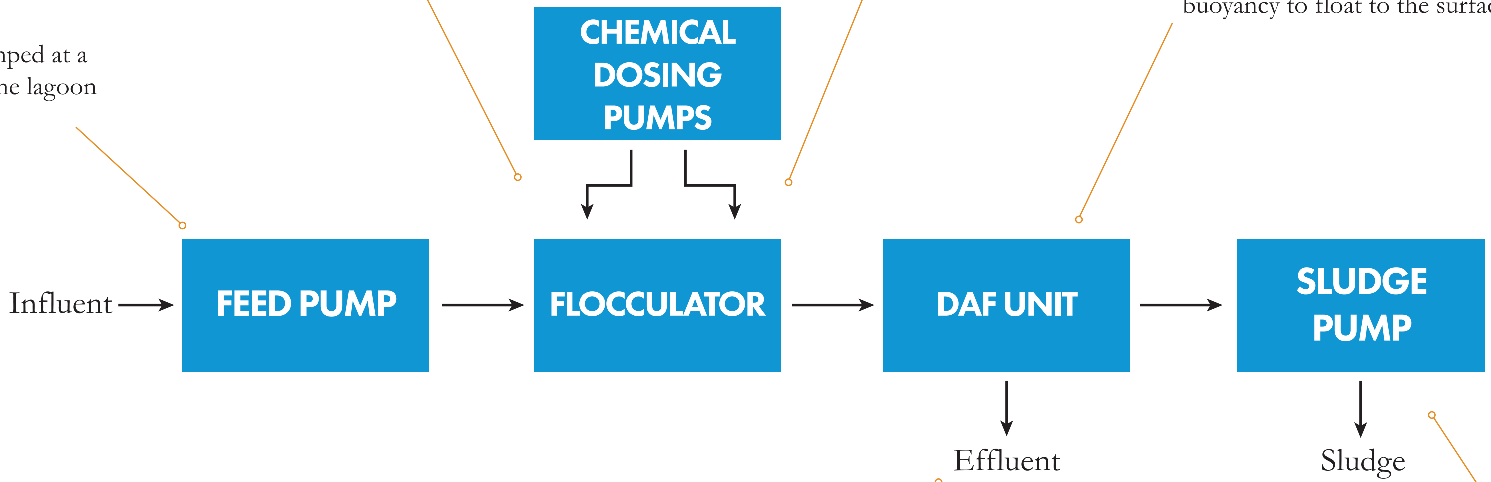
The DAF system used for this pilot study is a rectangular vessel constructed of stainless steel that is fitted with a flight-and-chain skimmer assembly, recycle pump, air dissolving tube, bottom auger, and instruments for measuring flow rate, water level, and pH. The general sizing parameters of the DAF unit are given in the table to the right.

DAF DESIGN PARAMETERS

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

PROCESS OVERVIEW

The DAF system for the pilot study followed a chemical/physical separation process as outlined below:



1. Wastewater is pumped at a constant rate from the lagoon into the flocculator.

2. A coagulant is dosed at the front end of the flocculator to form "micro flocs" which have a positive (+) charge.

3. A flocculant is injected to agglomerate coagulated particles into larger "macro flocs" that float more readily in the DAF tank.

4. Water flows into the DAF tank and is hit with a stream of 30-50 micron sized air bubbles which attach to the solid particles and give them buoyancy to float to the surface of the tank.

5. As sludge accumulates on the water's surface, a skimmer pushes it into a collection chamber for removal.

6. Clarified water is discharged from the DAF unit back into the lagoon. On a full-scale system, treated effluent would be discharged to the local waterway.

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

DID YOU KNOW???

The greatest expense in operating a DAF system isn't in the hardware, but in ongoing chemical consumption. Identifying the right chemicals and dosing rates can save tens of thousands of dollars per year.

PILOT RESULTS

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

OWNER'S ANALYSIS

	Phosphorus (mg/L)		TSS (mg/L)		CBOD (mg/L)	
	DAF Influent (from lagoon)	DAF Effluent	DAF Influent (from lagoon)	DAF Effluent	DAF Influent (from lagoon)	DAF 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
Averages	**1.07**	**0.50**	**31.92**	**4.45**	**23.97**	**6.38**
Percent Reduction	53.74%		86.07%		73.40%	

THIRD-PARTY ANALYSIS

	Phosphorus (mg/L)		TSS (mg/L)		CBOD (mg/L)	
	DAF Influent (from lagoon)	DAF Effluent	DAF Influent (from lagoon)	DAF Effluent	DAF Influent (from lagoon)	DAF 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	60.78	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
Averages	**1.29**	**0.42**	**30.53**	**3.94**	**34.87**	**1.54**
Percent Reduction	66.93%		87.08%		95.57%	

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, consistantly reducing phosphorus concentration to less than 1 mg/L in jar tests and in the DAF effluent.

PAC 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

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

SOLIDS LOADING RATE

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

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

* 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

AIR-TO-SOLIDS RATIO

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

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

SUMMARY

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 discrepencies 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 consistantly achieved the desired TSS, TP, and CBOD removal rates to bring the facility within permitted discharge limits.

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

Properly treated, the DAF effluent was essentially devoid of algae and appeared crystal clear

ABOUT FRC SYSTEMS

FRC was founded in 1979 with the goal of delivering trusted wastewater treatment solutions. Over 35 years, FRC has completed more than 500 installations in 20+ countries around the globe and become the eminent DAF systems provider in the private and public sectors.

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