JUST ADD WATER

W H I T E P A P E R

The Leopold® Clari-DAF™ System Improves Wastewater Lagoon Effluent

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Wastewater lagoons typically are used as the preferred method of treatment where there is domestic waste, sufficient land, and low flow rates. Typically the process involves one or two aeration ponds where the waste is exposed to biological treatment followed by a pond where solids are settled out. The flow is then discharged or reused. The settling stage is there to remove:

1. Suspended (including biological organism) and colloidal solids (TSS)
2. Precipitated dissolved solids
3. Biochemical Oxygen Demand (BOD) (associated with the solids)
4. Algae (usually during warmer summer weather conditions)

The Federal Clean Water Act regulates both BOD and TSS under the National Pollution Discharge Elimination System (NPDES) standards. The regulations place limits on discharges into surface waters as well as what minimum technologies must be in place by industry. Industry and municipalities are issued permits that allow them to discharge at specific regulated levels. Due to the regulated discharge limits, many systems are now required to add treatment practices to comply with their permit limits.

One method is to further clarify the lagoon effluent to improve TSS and BOD removal. The clarification equipment has a major impact on two areas: the effluent water quality to the receiving stream, and the solids leaving the process affects the volume of sludge to handle. The effluent quality must meet the required discharge limits while the sludge volume affects the cost associated with energy, chemicals, cake solids, and disposal.

In many cases, the Leopold® Clari-DAF™ (Dissolved Air Flotation) system is an excellent choice for clarification process equipment. In the Clari-DAF system process, particles are flocculated and separated out of the water by floating them to the surface, rather than settling them to the bottom of a basin. The process introduces micro-sized air bubbles through diffusers at the bottom of the contactor where it mixes with coagulated solids and floats the floc. The air bubbles are produced by recycling a portion of the effluent through a tank where air is introduced, the water saturated, and then reduced to ambient pressure, thus creating the pressurized flow. The floated sludge is removed from the top of the basin by mechanical or hydraulic means, while laterals from the bottom of the basin remove the clarified water.

The Clari-DAF system is particularly effective in removing low-density solids such as turbidity, color, algae, biological solids, or precipitated organic material and metals. These are all contaminants that do not settle well, but tend to float or hover in the water column. The Clari-DAF system can also handle rapid changes in temperature and influent water quality.

The Clari-DAF system is less costly than conventional sedimentation basins because the flocculation section is one-half to one-quarter in size. Depending on how the calculations are completed, the surface loading of the solids separation part of conventional DAF process can be up to 10 gpm/ft^2, while high-rate systems can be up to 20 gpm/ft^2. Some manufacturers calculate surface area by including the entire length of the flotation cell, while others calculate the rate using the clarified water collector area.

Since the particle removal is by flotation, rather than sedimentation, both the flocculation and clarification detention times are less than conventional treatment. The particle size for removal in flotation can be tens of microns rather than the hundreds of microns required for sedimentation, and the Clari-DAF System unit will produce a more consistent effluent quality. It will also produce sludge solids in the float of 2% to 5%, which reduces the sludge volume to handle and the cost of further processing whether by dewatering or hauling away the sludge solids.

In July 2000, the F.B. Leopold Company Inc. was invited by the Town of Johnstown, Colorado to conduct a pilot study utilizing the Clari-DAF system mobile pilot plant. The purpose of the study was to determine the performance level that could be achieved with this technology, particularly when algae were present in the final pond. The goals of the study were to determine design criteria with respect to loading, recycle rate, sludge quality and quantity, chemical consumption, and BOD and TSS effluent quality.

The influent to the pilot unit was drawn directly from the third pond using a submersible pump. Jar tests established that the optimum starting chemical dosage for the pilot test would be 100 mg/L of alum and 0.25 mg/L of poly DADMAC. The results of the 3-week pilot test are shown in Table 1.

Table 1
Results of Clari-DAF Pilot Test

Parameter	Clari-DAF Influent		Clari-DAF Effluent	
	Range	***Average***	***Range***	***Average***
Turbidity, NTU	18 - 80	40	2 - 28	15
BOD mg/L	24 - 35	27	3 - 13	10
TSS mg/L	19 - 62	35	8 - 25	11

The Clari-DAF system loading rate was varied from 4 to 8 gpm/ft² based on total surface area. Whether the Clari-DAF system unit was fed at the low rate or the high rate, the effluent remained the same good quality. The sludge produced contained 2% to 4% dry solids and the production volume averaged 0.4% of influent flow. A sludge drying bed test conducted during the pilot test produced cake solids of 6.88% after only 24 hours of operation.

Based on the pilot performance, a Leopold Clari-DAF system was purchased by the town, installed, and commissioned in late February 2004. The town also added additional aeration to the first two ponds, and a MBBR (Moving Bed Biofilm Reactor) nitrification process to convert ammonia to nitrate prior to sending the wastewater to the Clari-DAF system unit. Both resulted in more solids (biological) to remove in the clarification stage. A comparison of plant performance in terms of BOD, TSS, and coliforms is provided in Tables 2 and 3.

Table 2
Comparative Performance, Annual, Before and After Clari-DAF Installation

	BOD			TSS			Coliforms
	Plant Influent, mg/L	***Plant Effluent, mg/L***	***% Removal, mg/L***	***Plant Influent, mg/L***	***Plant Effluent, mg/L***	***% Removal, mg/L***	***Plant Effluent, Count***
Before Clari-DAF System Installation							
2001	308	8.8	97.1	186	25	86.6	255
2002	397	11	97.2	163	28	82.8	6,843
2003	233	9	96.1	184	23	87.5	3,777
After Clari-DAF System Installation							
2004 (2 mo)	270	16	94.1	285	16	94.3	18
2004 (10 mo)	201	1.2	99.4	180	8.1	95.5	5
2005	244	2.5	99	230	5.8	97.5	23

Table 3
Comparative Performance, Highest Month,
Before and After Clari-DAF Installation

	BOD		TSS		Coliforms	
	Highest Month	***Plant Effluent, mg/L***	***Highest Month***	***Plant Effluent, mg/L***	***Highest Month***	***Plant Effluent. Count***
Before Clari-DAF System Installation						
2001	Feb	22	Apr	63	Aug	1000
2002	Jan	36	Apr	120	July	2,930
2003	Dec	22	Jul	48	Dec	20,000
After Clari-DAF system Installation						
2004 (10 mo)	Mar	2.3	June	19	Nov	9
2005	Dec	8	Apr	9	Jan	107

Gaining operational experience since start-up, the plant personnel have reduced the alum dosage from 100 mg/L to 60 mg/L and eliminated the cationic poly DADMAC chemical feed entirely. This has reduced operating chemical cost as well as changed the nature of the sludge that was removed from the surface of the flotation cell. The sludge thickness was reduced, permitting more effective flushing of the sludge from the hopper. In addition, the normal summer algae blooms, typically found in the third pond, have had no affect on plant discharge. A bonus benefit has been noted with effluent coliforms now averaging 250 CFU/100 ml vs. pre-Clari-DAF system effluent coliforms of 5,000 CFU/100 ml.

The Clari-DAF system processes 400,000 gallons of wastewater per day, but is designed to operate at a higher loading rate to handle flows up to 750,000 gallons per day. Its location in the treatment plant allows for installation of a duplicate Clari-DAF system to accommodate future growth. The addition of a second Clari-DAF system would double plant capacity to 1.5 MGD.