

Case Study Summary:

Using ATP analysis to monitor live biomass levels during implementation of a bioremediation plan.

Problem: A wastewater treatment plant (WWTP) processing a combination of municipal, commercial, industrial waste, experiencing high sludge depths (5-7 ft) in treatment lagoons (10 ft depth), resulting in high risk of upset and limiting the facilities processing capacity. A bioremediation plan to decrease lagoon sludge levels was applied and the results were monitored.

Facility: Municipal Wastewater treatment plant (WWTP) in California, USA.

Investment: LuminUltra's QuenchGone21 Wastewater (QG21W) and PhotonMaster luminometer for measuring adenosine triphosphate (ATP).

Synopsis: A bioremediation plan was implemented which included the application of a biostimulant intended to encourage microbial reduction of the organic solids (ie. Sludge).

Sludge depth measurements were performed for 2 of 4 primary lagoons prior to biostimulant treatment and at quarterly intervals for one year to measure the impact of bioremediation. ATP analyses were performed to monitor live biomass energy levels throughout the bioremediation process and DNA analyses were used to monitor the presence and relative abundance of prokaryote species. The results of the ATP analyses revealed that WWTP lagoon sludge is biologically active, and it can be controlled and reduced through bioremediation interventions.

Case Study:

Using ATP analysis to monitor live biomass levels and stress during implementation of a bioremediation plan.

Summary

A wastewater treatment plant (WWTP) located in California processing a combination of municipal, commercial, and industrial waste using four lagoons (1A, 1B, 2, 3) was experiencing excessive sludge depths, decreasing the facility's wastewater processing capacity. A bioremediation plan was devised and implemented with Probiotic Solutions® to reduce sludge levels and return the WWTP to normal operation.

In addition to the primary goal of reducing lagoon sludge levels, ATP and DNA analyses were used to monitor specific changes to the microbial community in two lagoons (1A, 1B) throughout the course of the bioremediation. Sludge depth was measured, ATP levels were quantified to assess microbial viability, and DNA analysis was used to describe the bacterial community members present.

For full details refer to Lagoons: Under the Surface - Heather Jennings, PE, Sr. Project Engineer, Probiotic Solutions®

Setup

With a total wastewater influent to the WWTP system of 2.8 million gallons/day, primary lagoons (1A, 1B) each hold approximately 25 million gallons and operate in parallel, while secondary (2), and tertiary (3) lagoons operate in series. Baseline sludge depth assessments found sludge depths > 5 ft at many of the 30 sampling points in each primary lagoon (1A, 1B) while only having average total depths of 10 ft.

Following initial sludge depth assessment, a bioremediation product (Probiotic Solutions - Bio Energizer®) consisting of complexing agents, organic acids, natural biological stimulants, and nutrients was applied to shift the microbial ecosystem towards increased bio-oxidation capacity. The biostimulant product was added to the inlets of both primary lagoons (1A, 1B) on November 29, 2018 at an initial concentration of 7 ppm (7 gallons of product to 1,000,000 gallons of influent), decreasing to 5 ppm on September 1, 2019, and ultimately reduced to a maintenance dose of 3 ppm on November 19, 2019.

Sludge depth assessments were performed quarterly throughout the bioremediation processes' one year duration, wherein samples for ATP (and DNA) analyses were collected from the following three layers: bottom layer of compressed thick "sludge", "interstitial" middle layer, and upper liquid "supernatant" across three cross-sections per lagoon using a modified "Sludge Judge". Samples along these cross-sections were collected into three 30 ml composite sample per cross-section (3 cross-sections X 3 samples / cross-section = 9 samples from each layer / lagoon). 20 ml of each composited sample was analyzed with a LuminUltra QuenchGone21 Wastewater test protocol for Total ATP (tATP), Cellular ATP (cATP) to measure living biomass / energy level, Dissolved ATP (dATP) to measure extracellular ATP, and Biomass Stress Index (BSI) as a measure of the relative health of living biomass, while the remaining 10 ml was used for DNA analysis.

Results & Discussion

Sludge levels

Initial baseline average sludge depth measurement for both lagoon 1A and 1B was 3.4 ft, although depths were variable across sampling points, with several depth measurements over 5 ft (Figure 1 - A,B). Although total influent was divided evenly between lagoons (1A = 50% / 1B = 50%) at study onset, septicity issues in 1A were detected in January 2019, which necessitated a diversion of influent volume to 1B (1A = 30% / 1B = 70%) until November 2019.

At the end of the study period, 1A had an average sludge depth of 1.63 feet, with a complete absence of sludge layer at 10 sampling locations (Figure 1 - C), and 1B had an average sludge depth level of 1.99 feet and 5 sampling locations with no sludge layer (Figure 1 - D). Overall, the average sludge depth reduction for 1A was 1.68 ft and 1.46 ft for 1B.

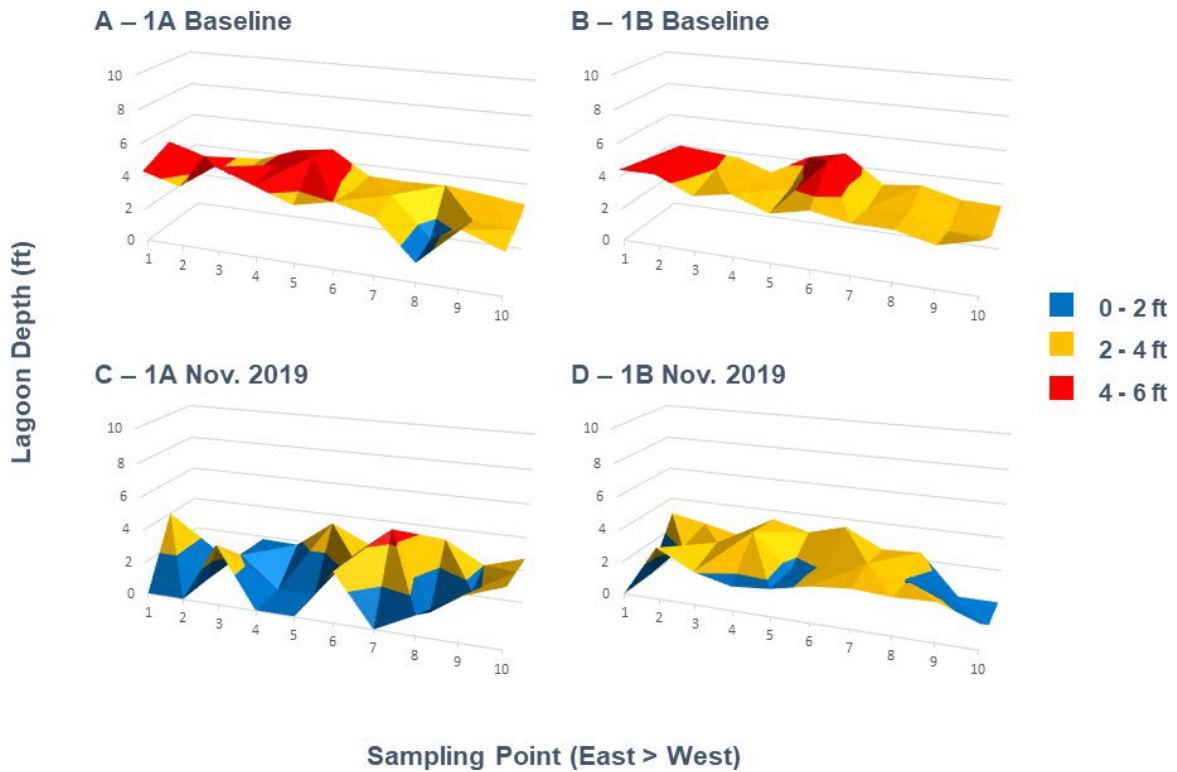


Figure 1: Sludge depth measurements

ATP

The ratio of Cellular ATP to Dissolved ATP (cATP:dATP) and Biomass Stress Index (BSI) was calculated for each sample, essentially comparing living and dead biomass energy levels and measuring the relative living biomass health. ATP measurements showed that the sludge layer was highly bioactive, with variable levels of activity during the sampling period (Figure 2).

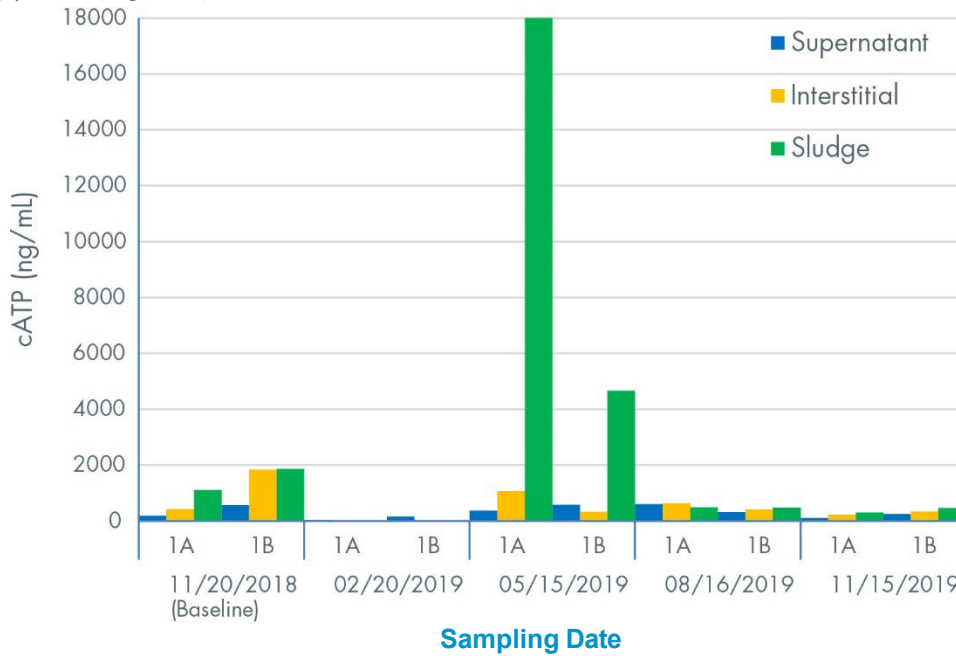


Figure 2: Cellular ATP (cATP) measured per sampling layer

During quarterly sampling, lagoons 1A and 1B showed signs of suppression in February 2019, possibly the result of a rapid influent pH swing. Following this event, 1A went septic and 1B was strained, indicated by average cATP:dATP ratios of 0.49 in 1A and 0.38 in 1B (Table 1). BSI calculations for this sampling period also indicating high stress, with an average BSI of nearly 70% for 1A and above 80% for 1B (Table 1).

ATP measurements showed that recovery for each lagoon was quickest near the influent site, where consistent receipt of new organic solids mitigated the effects of sludge removal. Interestingly, sampling points closest to the effluent sites from both lagoons 1A and 1B towards downstream lagoon 2 showed a delayed suppression during May 2019 sampling, indicating prolonged impact from the toxic upset event. Finally, the quarterly BSI measurements were averaged for 1A (59.5) and 1B (25.5), which clearly indicated that the relative living biomass stress level present in 1A was higher than in 1B, despite the previously mentioned higher proportion of influent directed towards lagoon 1B.

Table 1 - QG21W Test Results (Average Values)

Sampling Date	Lagoon	AVSS (mg/L)	BSI (%)	cATP (ng/mL)	dATP (ng/mL)	tATP (ng/mL)	cATP:dATP
11/20/2018	1A	550.95	14.44	1101.91	185.50	1287.41	8.83
	1B	928.97	12.87	1857.94	310.90	2168.84	7.49
02/20/2019	1A	6.94	69.95	13.88	22.56	36.45	0.49
	1B	5.77	80.33	11.55	52.78	64.32	0.38
05/15/2019	1A	9192.46	25.54	18682.17	40.72	18722.88	407.66
	1B	2333.30	7.34	4666.60	34.77	4701.36	247.71
08/16/2019	1A	245.47	18.52	490.95	57.46	548.40	6.84
	1B	235.71	12.59	471.42	40.09	511.50	8.69
11/15/2019	1A	87.54	8.54	299.88	30.38	330.27	11.01
	1B	230.96	9.63	461.93	37.35	499.27	9.12

Impact & Conclusions

Using LuminUltra's QG21W ATP analysis kit, it was found that the bottom sludge layer was the most biologically active layer of the lagoons, indicating that this layer, previously thought to be inert, represents an ideal target for bioremediation (Figure 2). Evidence of this was clear during the final assessment of sludge depth in November 2019, when the average reduction of sludge from lagoon 1A was 1.68 ft (48%) and 1.46 ft for Pond 1B (42%), which represents a reduction of almost 9.4 million gallons of sludge and an average yearly removal rate of 99.8% of Biochemical Oxygen Demand (BOD). By extension, an additional 57.4 million gallons of solids per year were treated in addition to what was removed, for a total reduction of 66.8 million gallons of sludge during the study period (sludge removed

+ additional sludge treated). With a total reduction of ~18,000 dry tons (6% conversion) and an estimated \$340 US / ton removal cost, potential savings exceed \$6 million US plus reduction in dredging downtime for a remediation investment of ~\$350,000 US.