EFFECTS OF MIXING RATIO, CONTACT TIME, DO, AND EPS COMPOSITION ON EFFICIENCY OF BIOSORPTION FOR PRIMARY CARBON DIVERSION

A THESIS SUBMITTED TO THE GRADUATE DIVISION OF THE UNIVERSITY OF HAWAIʻI AT MĀNOA IN PARTIAL FULFULLMENT OF THE REQUIREMENTS FOR THE DEGREE OF

MASTER OF SCIENCE

IN

CIVIL AND ENVIRONMENTAL ENGINEERING

DECEMBER 2019

By

Joachim Schneider

Thesis Committee:

Roger Babcock, Chairperson
Tao Yan
Samir Khanal

Keywords: Biosorption, EPS, Activated Sludge, Carbon Diversion, Enhanced Primary

Abstract:

Wastewater treatment plants are on their way to going from being energy sinks to becoming energy-neutral or even energy-positive utilities. This is possible thanks to improvements in their processes such as primary treatment. Conventional primary wastewater treatment removes a large part of particulate organics but allows the soluble fraction to pass on to secondary treatment. In this paper, the combination of biosorption and solid-liquid separation is tested as an alternative primary treatment method that can remove both particulate and soluble organics. Results show that while the combination of biosorption and fine screens with polymer removes a sizeable amount of particulate (50 to 70 per cent) and soluble (10 to 30 per cent) organic matter, the use of fine screens with polymer without biosorption achieves almost the same removal rates. Further insights were found regarding the isotherm and kinetics of biosorption, oxygen concentration and mixing ratios in the contact tank, and differences between various solid-liquid separation methods.

Extracellular polymeric substances make up most of the organic matter in activated sludge, and therefore strongly influence the sludges properties. This paper aims to draw a connection between the make-up of an activated sludge's extracellular polymeric substances and its ability to conduct biosorption when mixed with raw wastewater. Biosorption is a natural process during which organic matter from a sorbate such as raw wastewater sorbs onto a sorbent such as activated sludge, a process which can be used during primary wastewater treatment. A positive correlation was found between the total concentration of extracellular polymeric substances and the normalized removal of soluble organic matter. It was furthermore postulated that extracellular polymeric substances, specifically proteins, comprised most of the soluble organic matter removed during biosorption. Extraction times of 4 or more hours yielded better identification of extracellular polymeric substances and more consistent ratios between proteins, carbohydrates, humic acids, DNA, and uronic acids than extraction times of 45 minutes.

Table of Contents:

Article

Effects of Mixing Ratio, Contact Time, and DO on Efficiency of Biosorption for Primary Carbon Diversion

Joachim Schneider [1], Roger Babcock Jr [1,*], Tiow-Ping Wong [1], and Bing Hu [1]

[1] University of Hawai'i at Mānoa; js73@hawaii.edu
* Correspondence: rbabcock@hawaii.edu; Tel.: 808-956-7298

Abstract: Wastewater treatment plants are on their way to going from being energy sinks to becoming energy-neutral or even energy-positive utilities. This is possible thanks to improvements in their processes such as primary treatment. Conventional primary wastewater treatment removes a large part of particulate organics but allows the soluble fraction to pass on to secondary treatment. In this paper, the combination of biosorption and solid-liquid separation is tested as an alternative primary treatment method that can remove both particulate and soluble organics. Results show that while the combination of biosorption and fine screens with polymer removes a sizeable amount of particulate (50 to 70 per cent) and soluble (10 to 30 per cent) organic matter, the use of fine screens with polymer without biosorption achieves almost the same removal rates. Further insights were found regarding the isotherm and kinetics of biosorption, oxygen concentration and mixing ratios in the contact tank, and differences between various solid-liquid separation methods.

Keywords: biosorption; carbon diversion; net-zero energy; dissolved air flotation; fine screens; primary wastewater treatment; kinetics; polymer

---

1. Introduction

During wastewater treatment, energy is both produced and consumed. In 2011, wastewater treatment plants (WWTPs) accounted for 0.8 per cent of the electricity consumption in the USA, half of which was used in secondary treatment for aeration [1]. Anaerobic digestion is commonly used to stabilize treatment sludges and can be a net producer of energy. The goal of primary wastewater treatment must therefore be to divert the carbon-energy contained in the untreated influent from the aeration-bound liquids stream to the solids stream, where it can be harvested by means of anaerobic digestion. Two positive effects are thereby achieved: the oxygen demand and therefore electricity consumption in the secondary treatment is reduced, and the methane production and therefore energy scavenging in the anaerobic digester is increased. It is hypothesized that achieving net-zero energy for a WWTP is possible in this way [2].

Conventional primary wastewater treatment by means of gravity sedimentation removes between 40 and 60 per cent of suspended solids (TSS), and between 20 and 30 per cent of biological oxygen demand (BOD) by capturing particulate matter but does not reduce the soluble fraction of raw influent organics. There is a current industry trend toward the use of primary screens, filters, and floatation devices for enhanced capture/diversion of raw solids, which can achieve removals of up to 60-80 per cent of particulate organics, but similarly do not reduce the soluble fraction [3]. Biosorption can be used to remove the soluble fraction. It is used in various industries for the removal of heavy metals [4] and organic pollutants [5], and is a fundamental step in the activated sludge process prior to biochemical oxidation. Primary biosorption is a biochemical process in which waste activated sludge (AS), the adsorbent, is mixed with raw wastewater (RW) in a small contactor where the particulate and soluble organic matter adsorb onto the AS flocs [6]. The amount of sorption is dependent on physiological factors such as dissolved oxygen (DO) concentration, contact time and AS-to-RW ratio.

Research has found that the colloidal fraction of organic matter is targeted significantly more during biosorption than the particulate and truly soluble fractions [6]. It is assumed that this is because soluble matter diffuses into the floc matrix while colloidal matter sticks to the outside [7]. It was found that only aerobic sludge is suitable for biosorption because neither primary nor digested sludge yielded positive results [8].

Since the biosorption contactor effluent is high in TSS, a solid-liquid separation process is required to harvest the adsorbed materials. Potential separation processes include cloth filters, fine screens, and dissolved air flotation (DAF), the latter two of which were compared here. The combination of biosorption with DAF has been tested on a pilot- and a full-scale, and was found to be capable of high removals of soluble BOD (20 to 30 per cent) and TSS (more than 65 per cent) while generating thick sludge (4 to 6 per cent) in the DAF [9].

This study conducted bench-scale evaluations of biosorption for effects of contact time, DO, and AS-to-RW mixing ratio on efficiency and also looked at adsorption kinetics.

2. Materials and Methods

AS and coarsely screened RW samples were collected no more than two hours before use and stored at ambient temperature during transportation to the lab, not chilled. Samples were taken at a regional treatment plant receiving municipal influent with no industrial component which is designed to treat 13 million gallons per day by means of a trickling filter solid contact system (TF/SC).

To simulate the biosorption process on a bench scale, RW and AS were combined in a five-liter Plexiglass tank (contactor) and stirred at room temperature for 10 to 90 minutes on a stir plate by means of a magnetic bar, while DO concentrations were held constant at either 0.5 or 1.0 mg l^{-1} and measured using Standard Method 4500-O G [10]. RW, AS, and biosorption contactor effluent were characterized via total chemical oxygen demand (tCOD), soluble COD (sCOD), flocculated and filtered COD (ffCOD) and TSS. Experiments were conducted with mixing ratios of five (MX5) or ten (MX10) per cent AS by volume, yielding doses of approximately 1.2 or 2.5 mg of AS TSS per mg of RW sCOD, respectively. MX5 is a similar ratio of AS TSS to RW sCOD that would occur at the subject TF/SC facility if all of the AS and RW were combined in a biosorption contactor (ratio 1.16 to 1.34). Normalized biosorption was calculated similarly to Jorand et al. [6] by dividing the removed COD by the TSS added (see Equation 1).

$$\text{Normalized Biosorption } [\text{mg}_{\text{COD}}\ \text{g}_{\text{TSS}}^{-1}] = \frac{\text{COD}_{\text{RW}}\ [\text{mg}] - \text{COD}_{\text{EFF}}\ [\text{mg}]}{\text{TSS}_{\text{AS}}\ [\text{g}]} \quad (1)$$

Colloidal COD (kCOD) was defined as the difference between sCOD and ffCOD (see Equation 2).

$$\text{kCOD}\ [\text{mg}\ \text{l}^{-1}] = \text{sCOD}\ [\text{mg}\ \text{l}^{-1}] - \text{ffCOD}\ [\text{mg}\ \text{l}^{-1}] \quad (2)$$

In order to find the kinetics governing the biosorption process, replicate experiments were conducted for both 60- and 90-minutes contact time with sampling every ten minutes. These experiments utilized five per cent AS and 1.0 mg l^{-1} DO concentration. An attempt was made to find an isotherm relationship by running the biosorption experiment five times (with the same RW and AS), each time using five liters of RW mixed with either 100, 200, 300, 400 or 500 ml of AS. Experimental parameters for the isotherm experiment were 30 minutes of contact time and 1.0 mg l^{-1} DO concentration.

In order to simulate DAF separation, tap water was pressurized to 414 kPa (60 psi) and the pressurized vessel that was vigorously shaken. 150 ml pressurized tap water was added to 850 ml of biosorption effluent in a one-liter graduated cylinder in which a float formed separate from the subnatant. After 3 minutes, the subnatant was sampled for COD and TSS and designated Lab DAF effluent (see Supplementary Document 4). Since DAF processes use pressurized DAF effluent instead of tap water, the DAF separation was conducted a second time using pressurized Lab DAF effluent instead of tap water. DAF was also conducted on RW samples alone.

A second solid-liquid separation method (fine screens) was evaluated by pouring biosorption effluent through metal screens with openings of either 200 or 300 μm and sampling the filtrate. In some cases, 10 mg l^{-1} of CEP 414 cationic polymer was added before the filtration process, indicated by the letters PS before the screen size, while experiments without added polymer were labeled with the letter S. Screening was also conducted on RW samples alone.

Total COD (tCOD) was measured by means of Hach method 8000 which is based on Standard Method 5220D [10]. sCOD was measured by filtering the sample through a 1.5 μm glass fiber filter and measuring the COD of the filtrate. ffCOD was measured according to the method of Mamais et al. [11] using 30 ml of sCOD filtrate and 0.3 ml of zinc sulfate solution. TSS was measured by Standard Method 2540B [10].

Statistical analyses including t-test, r^2 and ANOVA were conducted in Microsoft Excel using the Data Analysis ToolPak Add-in.

3. Results and Discussion

3.1. Biosorption

Average (± standard deviation) of biosorption contactor influent and effluent concentrations, removal percentages and normalized biosorption values for all 53 experiments conducted are shown in Table 1. A master table with all biosorption experiment results can be found in Supplementary Document 2.a. The data show that truly soluble ffCOD removal is 21% while colloidal kCOD removal is much more efficient at 58%, however, this occurs because the amount of kCOD is much lower and the normalized removal values show that nearly the same net mass of kCOD and ffCOD are biosorbed per gram of adsorbent in 30 minutes contact time.

Table 1. Average Biosorption Results for all Experiments Conducted, n=53

	Average Influent (RW) Concentration [mg l^{-1}]	Average Effluent Concentration [mg l^{-1}]	Average Removal [%]	Average Normalized Removal [mg g_{TSS}^{-1}]
sCOD	150±21	103±18	31	178±83
ffCOD	113±19	88±18	21	89±43
kCOD	37±12	15±11	58	90±83

3.1.1. DO Concentration Effects

The effect of DO on biosorption was evaluated by testing two DO concentrations at 30 minutes of contact time. Average (± standard deviation) biosorption removal efficiencies at 0.5 and 1.0 mg l^{-1} DO are shown in Table 2. The data indicate that within this range of DO values, the net mass of ffCOD and kCOD biosorbed in 30 minutes are approximately equal and differences are not statistically significant at α=0.05 due to variance (see Supplementary Document 3.a.i). It is possible that lower DOs would adversely affect biosorption, and that higher DOs could affect biosorption either positively or negatively. However, providing greater DO than that resulting from the need for adequate mixing to provide contact between adsorbent and adsorbate could facilitate undesirable bioxidation in the contactor.

Table 2. Average Biosorption Results for Different DO Concentrations at 30 min Contact, n=53

	Average Normalized Removal DO = 0.5 [mg g_{TSS}^{-1}]	Average Removal DO = 0.5 [%]	Average Normalized Removal DO = 1.0 [mg g_{TSS}^{-1}]	Average Removal DO = 1.0 [%]	P(T<=t) two-tail at α=0.05
sCOD	173±85	30	180±78	31	0.81
ffCOD	79±36	20	93±45	22	0.23
kCOD	94±81	62	88±84	56	0.82

3.1.2 AS Mixing Ratio Effects

The effect of the mass of adsorbent on biosorption (the dose) was evaluated by testing two AS mixing ratios; 5% AS by volume (MX5) and 10% (MX10) at 30 minutes contact time. MX5 and MX10 are equivalent to adsorbent doses of 1.17 and 2.48 $mg_{TSS}\ mg_{sCOD}^{-1}$, respectively. Average (± standard deviation) biosorption removal efficiencies at MX5 and MX10 are shown in Table 3. The data indicate that greater adsorbent addition only slightly improved overall biosorption efficiency in 30 minutes contact time and that mass adsorbed per unit mass of adsorbent decreases, however, these differences are not statistically significant at α=0.05 due to variance (see Supplementary Document 3.a.ii). This phenomenon could be explained as equilibrium not being achieved at the higher dose in 30 minutes contact. In practical terms, the mixing ratio (adsorbent dose) would not be a variable parameter, instead, all of the waste AS would be directed to the contactor followed by a separation/thickening step. While the contact time is a design variable, once the contactor is sized, the time available for adsorption to approach equilibrium is fixed. These results show that it is not significantly beneficial to operate the overall system so as to generate larger adsorbent doses. The effects of contact time are investigated below.

Table 3. Average Biosorption Results for Different AS Mixing Ratios, n=53

	Average Normalized Removal MX5 [mg g_{TSS}^{-1}]	Average Removal MX5 [%]	Average Normalized Removal MX10 [mg g_{TSS}^{-1}]	Average Removal MX10 [%]	P(T<=t) two-tail at α=0.05
sCOD	205±88	29	165±78	31	0.11
ffCOD	96±44	19	86±42	22	0.45
kCOD	110±95	63	81±76	55	0.28

3.1.3 Biosorption Kinetics

Zero-order kinetic coefficients were found for sCOD and ffCOD biosorption removals between 10 and 90 minutes of contact time, with 3.1 mg of sCOD and 3.0 mg of ffCOD removed on average per minute and gram of TSS added. The quality of the linear fits was indicated by r^2 values over 0.7528 for sCOD and 0.6892 for ffCOD (Figures 1 and 2), and ANOVA Significance F values of less than 0.0104 for sCOD and 0.0191 for ffCOD (see Table 4). No statistically significant fit was found for kCOD (Figure 3). Given that sCOD and ffCOD removal occur at very similar rates, and that kCOD removal seems to be unaffected by time, it is assumed that kCOD sorption occurs almost instantaneously upon the mixing of RW and AS, while ffCOD sorption is a function of time (see Figure 4). Research has also shown that desorption of colloidal material is possible, and that kCOD removal reached equilibrium before ffCOD removal does [7]. It is possible that zero-order kinetics do not apply between zero and ten minutes of contact time, but this was not evaluated here because it is not thought to be practical to use less 10 minutes contact at full-scale. These results indicate that equilibrium is not achieved even at contact times of 90 minutes which is much greater than practical contact times of 15 to 30 minutes.

Table 4. Kinetic Coefficients and Regression Information

Exp.	sCOD Kinetic Coefficient [mg g_{TSS}^{-1} min^{-1}]	sCOD r^2	sCOD ANOVA Significance F	ffCOD Kinetic Coefficient [mg g_{TSS}^{-1} min^{-1}]	ffCOD r^2	ffCOD ANOVA Significance F
1	3.7	0.8381	0.0104	3.5	0.7832	0.0191
2	2.4	0.9524	0.0009	2.7	0.8089	0.0147
3	2.4	0.7920	0.0013	1.6	0.6892	0.0056
4	4.0	0.7528	0.0024	4.1	0.8595	0.0003
Reg.	3.1	N/A	N/A	3.0	N/A	N/A

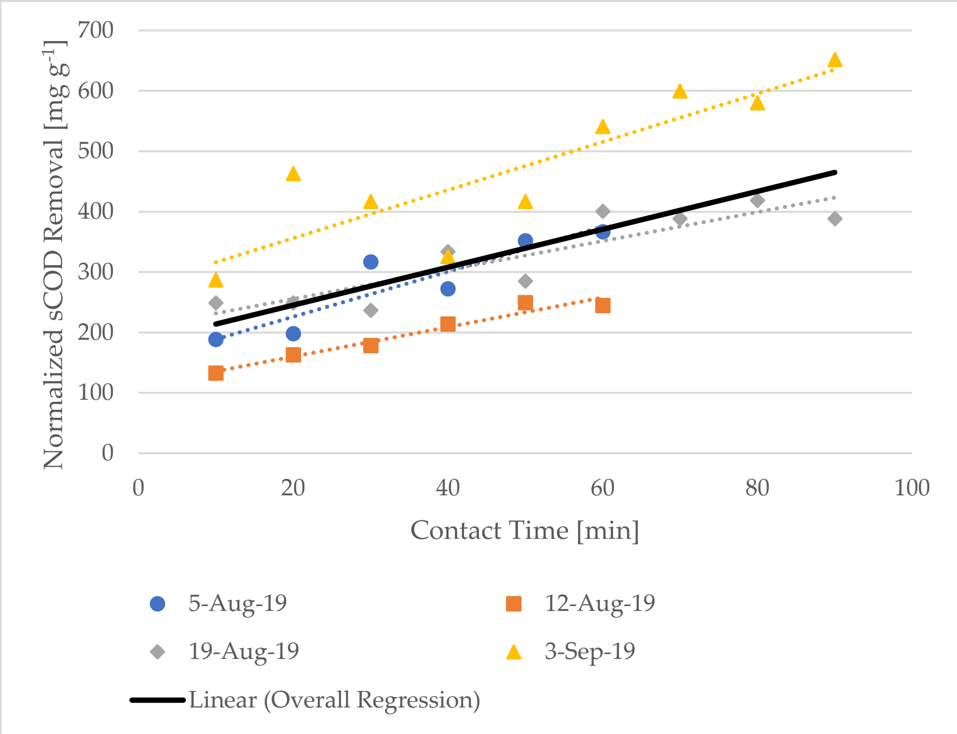


Figure 1. Kinetics of sCOD Removal

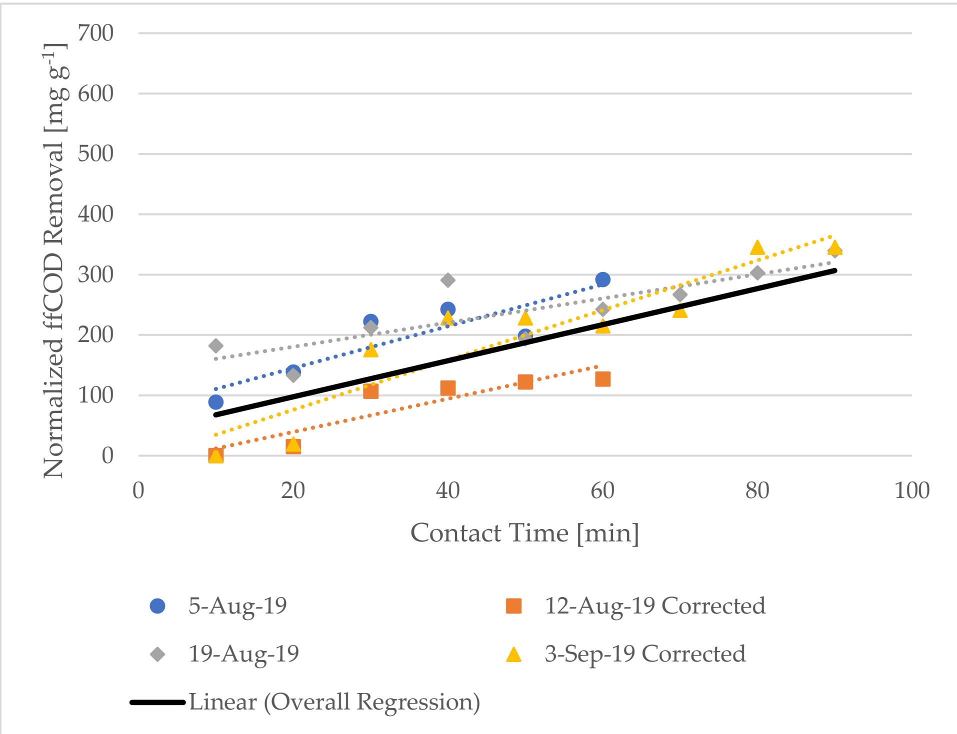


Figure 2. Kinetics of ffCOD Removal

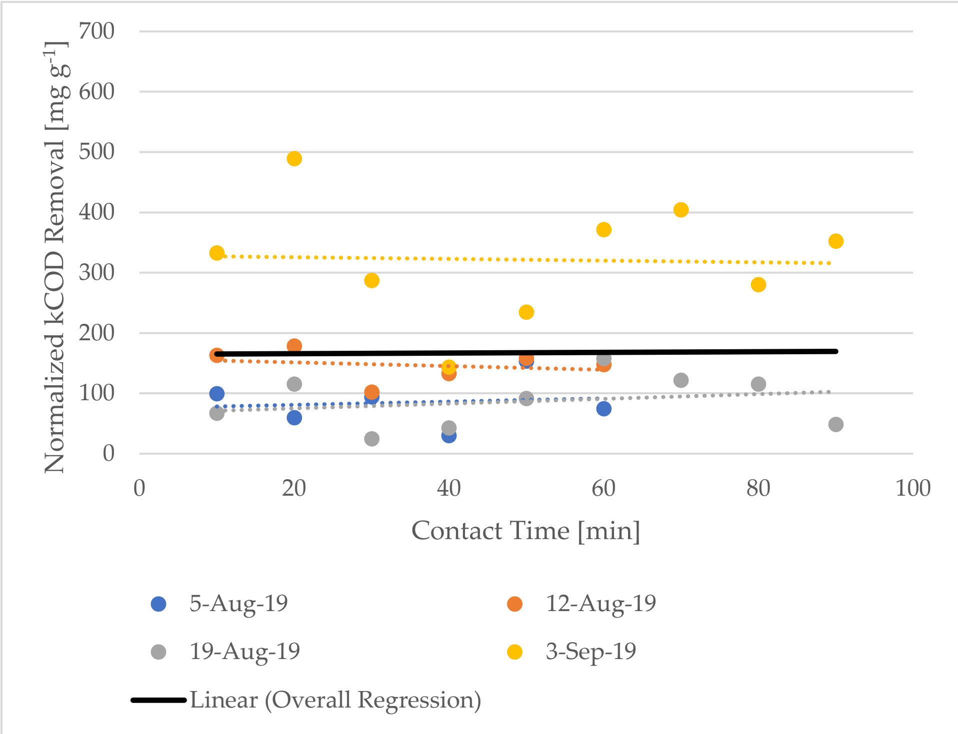


Figure 3. Kinetics of kCOD Removal

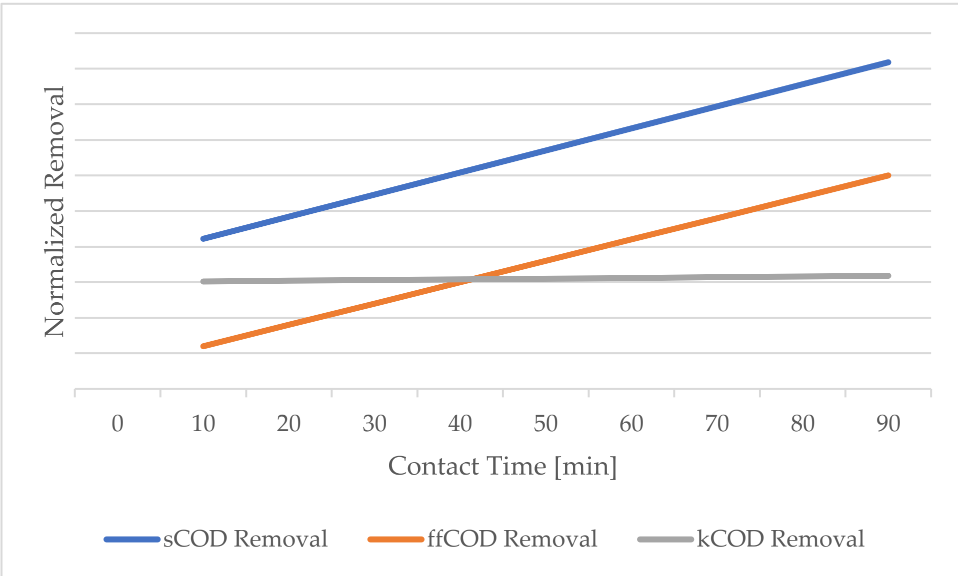


Figure 4. Qualitative Representation of Biosorption Kinetics

3.1.4 Isotherm

As AS doses increased, a decrease of normalized biosorption was observed (see Table 3). However, the more sorbent was added in the form of AS, the less normalized sorption increased leading to diminishing returns. It is assumed that the cause of this phenomenon is mass transfer limitations. The observed relationship between equilibrium concentration Ce and amount adsorbed qe did not make the creation of a Freundlich isotherm possible (see Supplementary Document 3.a.iii). No literature was found that was able to fit an isotherm, therefore it was not expected to be found here [7].

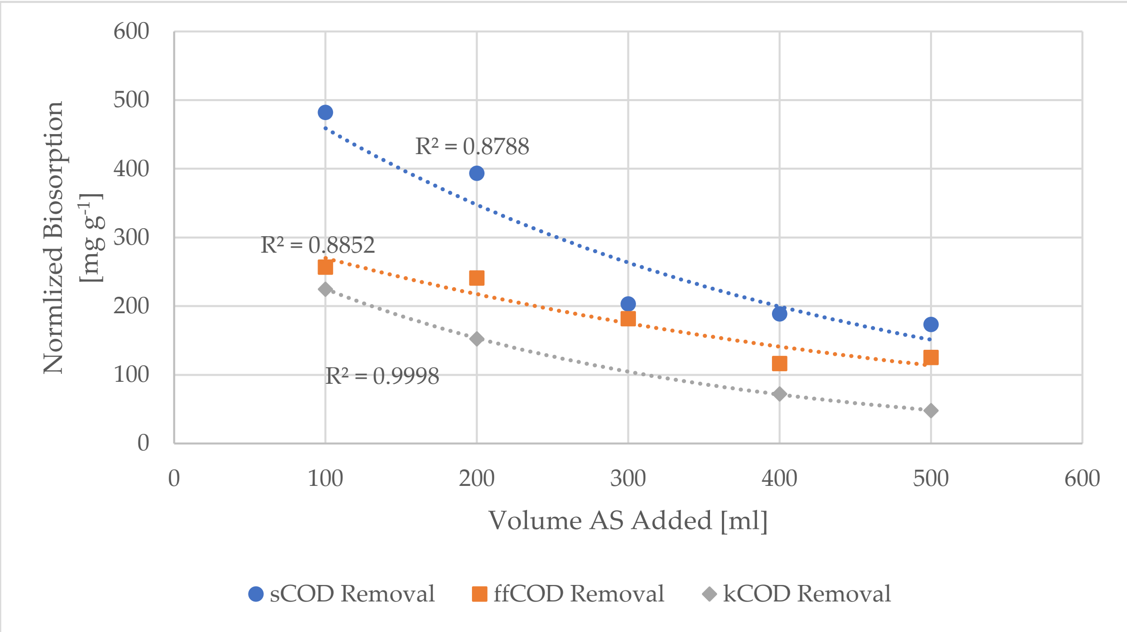


Figure 5. Effects of AS Dosage on sCOD, ffCOD, and kCOD Removal

3.2. Separation

The biosorption experiment was run before each separation process, and all removals mentioned here are in comparison to RW. Lab DAF measurements were corrected to account for the added tap water:

$$\text{Corrected Lab DAF } [\text{mg l}^{-1}] = {}^{\text{Lab DAF } [\text{mg l}^{-1}]}\!/_{0.85} \tag{3}$$

The effluents of the two solid-liquid separation processes, flotation and screening, did not differ significantly in terms of soluble COD removal at α=0.05. On average, between 166 and 208 mg of sCOD, 87 and 108 mg of ffCOD, and 77 and 124 mg of kCOD were removed per gram of added TSS (see Supplementary Document 3.a.iv).

In terms of tCOD and TSS, removal is used referring to percentages:

$$\text{tCOD Removal Percentage} = 1 - \frac{\text{tCOD}_{\text{EFF}}\ [\text{mg l}^{-1}]}{\text{tCOD}_{\text{RW}}\ [\text{mg l}^{-1}]} \tag{4}$$

$$\text{TSS Removal Percentage} = 1 - \frac{\text{TSS}_{\text{EFF}}\ [\text{mg l}^{-1}]}{\text{TSS}_{\text{RW}}\ [\text{mg l}^{-1}]} \tag{5}$$

By means of using screens without polymer, little to no tCOD and TSS removal was achieved. Screens with hole sizes of approximately 200 µm (S200) removed six per cent of tCOD and added 36 per cent of TSS, while S300 on average added 28 per cent tCOD and 82 per cent TSS (see Figures 4 and 5).

By means of flotation and using screens with polymer, significant tCOD and TSS removal was achieved. Lab DAF averaged 37 per cent tCOD and 33 per cent TSS removal, while WWTP DAF averaged 40 per cent tCOD and 36 per cent TSS removal. Screens with hole sizes of approximately 200 µm in combination with polymer (PS200) removed 61 per cent of tCOD and 55 per cent of TSS on average while PS300 averaged 61 per cent tCOD and 51 per cent TSS removal (see Figures 4 and 5).

It is not surprising that the different solid-liquid separation processes yield similar soluble COD removal rates, because it is assumed that the removal of soluble COD occurs in the biosorption step, and that the separation step does not affect soluble COD removal positively or negatively. The important differences between the separation methods can be found in their ability to reduce total

COD and TSS. In these categories, screens with polymer and DAF work best, while screens without polymer do not yield comparatively good results.

Table 5. Average Removal Values of Different Separation Methods (n=45)

	tCOD Removal Percentage	Normalized sCOD Removal [mg g_{TSS}]	Normalized ffCOD Removal [mg g_{TSS}]	Normalized kCOD Removal [mg g_{TSS}]	TSS Removal Percentage
S200	6%	208	118	89	-36%
S300	-28%	191	115	77	-82%
PS200	61%	211	87	124	55%
PS300	61%	204	98	106	51%
Lab DAF	47%	166	83	88	33%
WWTP DAF	40%	186	102	84	36%

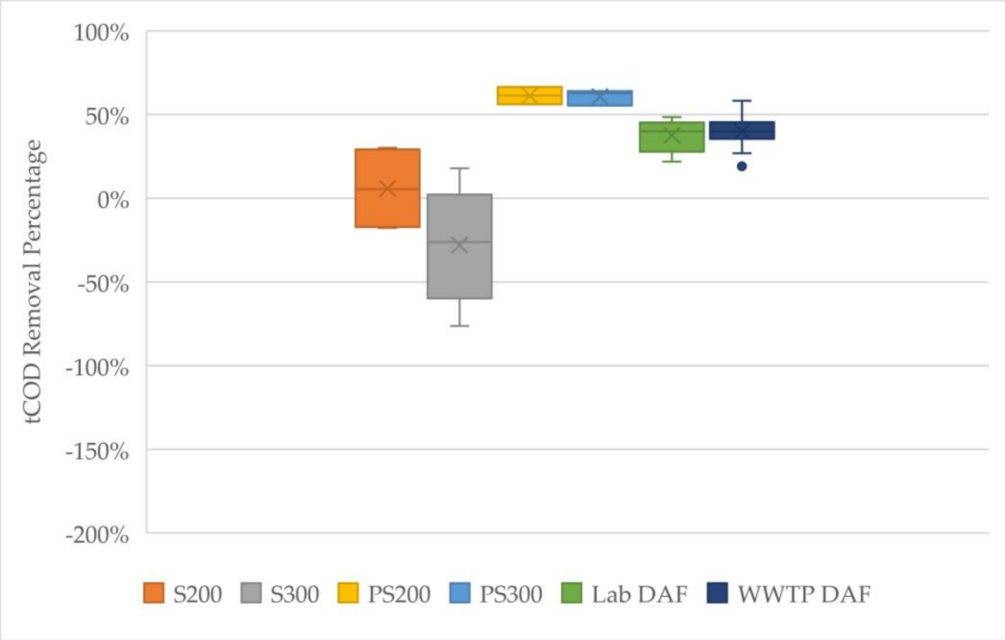


Figure 6. Total COD Removal Efficiencies of Different Solid-Liquid Separation Methods

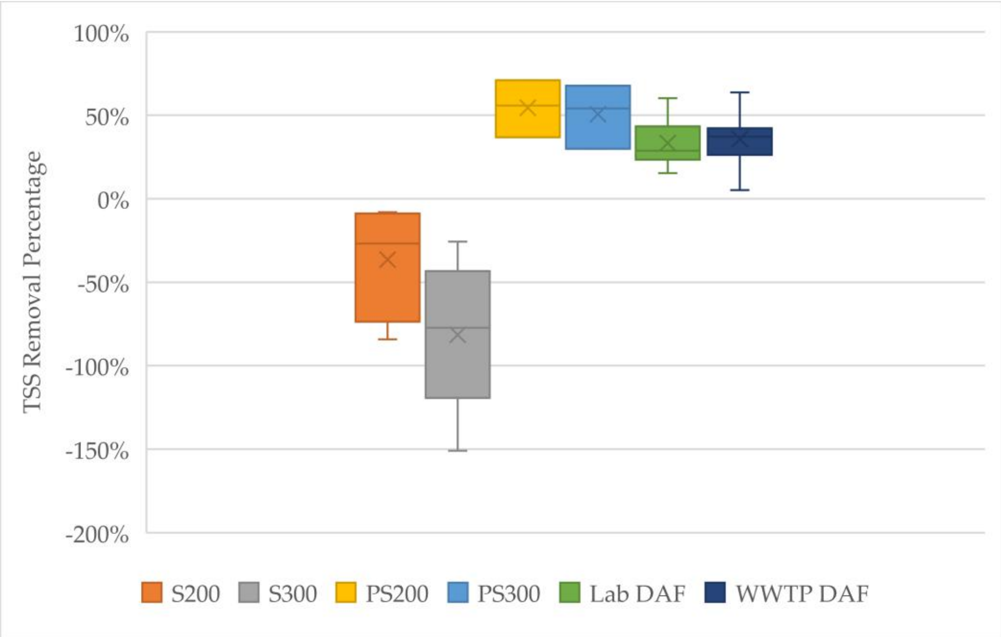


Figure 7. TSS Removal Efficiencies of Different Solid-Liquid Separation Methods

3.3 Is Biosorption Worth It?

In order to gauge the value of biosorption, results of biosorption experiments were compared to results of primary treatment methods that do not include a biosorption step, namely fine screens with and without polymer, and DAF. It was found that screens without polymer were only able to reduce tCOD by 30 or 32 per cent and TSS by 42 or 48 per cent, with virtually no effect on soluble organics. Screens with polymer reduced tCOD by 54 or 57 per cent and TSS by 63 or 65 per cent, including sCOD removals of 19 or 20 per cent, but virtually no ffCOD removal. DAF achieved 60 per cent tCOD and 63 per cent TSS removal, also removing 11 per cent of sCOD and 10 per cent of ffCOD (see Table 6).

The results of using screen with polymer or DAF on RW are comparable to using screens with polymer on biosorption effluent, therefore it seems as though the extra step of biosorption does not add value.

Table 6. Average Removal Percentages without use of Biosorption (n=16)

	tCOD	sCOD	ffCOD	TSS
WW S200	32%	1%	4%	48%
WW S300	30%	3%	2%	42%
WW PS200	57%	20%	0%	65%
WW PS300	54%	19%	-2%	63%
WW DAF	60%	11%	10%	63%

4. Conclusions

Adding AS to RW in order to facilitate better primary treatment seems counterintuitive, but it works. Using biosorption in combination with fine screens and polymer, tCOD removals of 60 per cent can be achieved, removing both soluble and particulate matter. However, similar removal percentages are reached by using biofiltration [3] or fine screens with polymer without biosorption, which means that the extra effort of adding AS does not provide additional carbon diversion. It is noted, however, that biosorption removes a significant portion of ffCOD, while methods without biosorption do not. The next comparison must now be drawn between conventional clarifiers and fine screens with polymer.

Funding: This research received funding from R.M. Towill.

References

1. Kinyua, M.N., et al., *The role of extracellular polymeric substances on carbon capture in a high rate activated sludge A-stage system.* Chemical Engineering Journal, 2017. **322**: p. 428-434.
2. H.-B. Ding, M.D., A. Erdogan, R. Wikramanayake, P. Gallagher, *Innovative Use of Dissolved Air Flotation with Biosorption as Primary Treatment to Approach Energy Neutrality in WWTPs.* Water Practice and Technology, 2015. **10**(1): p. 133-142.
3. Onder Caliskaner, G.T., Brian Davis, Javier Rios, Jessica Hazard, Julia Lund, Eric Lawrence, Darin St. Germain. *Demonstration of Biofiltration as Advanced Primary Treatment*. in *WEFTEC*. 2019. Chicago.
4. Comte, S., G. Guibaud, and M. Baudu, *Biosorption properties of extracellular polymeric substances (EPS) resulting from activated sludge according to their type: Soluble or bound.* Process Biochemistry, 2006. **41**(4): p. 815-823.
5. Wei, D., et al., *Role of extracellular polymeric substances in biosorption of dye wastewater using aerobic granular sludge.* Bioresource Technology, 2015. **185**: p. 14-20.
6. F. Jorand, J.C.B., P. Palmgren, Ph. Nielsen, V. Urbain, J. Manem, *Biosorption of wastewater organics by activated sludges.* 1995.

7. A. Guellil, F.T., J.-C. Block, J.-L. Bersillon, P. Ginestet, *Transfer of Organic Matter between Wastewater and Activated Sludge Flocs.* Wat. Res., 2001. **35**(1): p. 143-150.
8. Modin, O., et al., *Sorption and release of organics by primary, anaerobic, and aerobic activated sludge mixed with raw municipal wastewater.* PLoS One, 2015. **10**(3): p. e0119371.
9. N. Antonneau, M.D., B. Johnson, H. El Jerdi, R.W. Babcock Jr., T.P. Wong. *Biologically enhanced primary treatment: A summary of experience from pilot, demonstration, and full-scale systems*. in *WEF Residuals and Biosolids Conference*. 2018. Phoenix, Arizona, USA.
10. *Standard Methods for the Examination of Water and Wastewater*. 20th ed. 1999: APHA. 1325.
11. Daniel Mamais, D.J., Paul Prrr, *A rapid physical-chemical method for the determination of readily biodegradable soluble COD in municipal wastewater.* Water Research, 1993. **27**(1): p. 195-197.

Article

Effects of Activated Sludge EPS Composition on Biosorption

Joachim Schneider [1], Roger Babcock [1,*], Tiow-Ping Wong [1], and Bing Hu [1]

[1] University of Hawai'i at Mānoa; js73@hawaii.edu
* Correspondence: rbabcock@hawaii.edu; Tel.: 808-956-7298

Abstract: Extracellular polymeric substances make up most of the organic matter in activated sludge, and therefore strongly influence the sludges properties. This paper aims to draw a connection between the make-up of an activated sludge's extracellular polymeric substances and its ability to conduct biosorption when mixed with raw wastewater. Biosorption is a natural process during which organic matter from a sorbate such as raw wastewater sorbs onto a sorbent such as activated sludge, a process which can be used during primary wastewater treatment. A positive correlation was found between the total concentration of extracellular polymeric substances and the normalized removal of soluble organic matter. It was furthermore postulated that extracellular polymeric substances, specifically proteins, comprised most of the soluble organic matter removed during biosorption. Extraction times of 4 or more hours yielded better identification of extracellular polymeric substances and more consistent ratios between proteins, carbohydrates, humic acids, DNA, and uronic acids than extraction times of 45 minutes.

Keywords: biosorption; extracellular polymeric substances; cation exchange resin; activated sludge; primary wastewater treatment

1. Introduction

Extracellular polymeric substances (EPS) are most commonly defined as a combination of high-molecular-weight secretions from microorganisms, products of cell lysis, hydrolysis of macromolecules, and adsorbed organic matters from activated sludge (AS). They are described as having significant influence on the physicochemical properties of microbial aggregates, affecting their structure, surface charge, flocculation, settling and dewatering properties, and adsorption ability. EPS can furthermore serve as carbon or energy sources during nutrient shortages and accelerate the formation of microbial aggregates by binding cells closely [1].

There is an agreement within literature that more than half of organic matter contained in AS consists of EPS, but there is no consensus about what exactly constitutes EPS or how best to extract them. EPS are often grouped into loosely-bound EPS (LB-EPS), tightly-bound EPS (TB-EPS), and soluble EPS, also referred to as soluble microbial products (SMP). SMP can be extracted by centrifugation alone, but the extraction of bound EPS requires physical or chemical treatment in order to be released from the cell matrix before centrifugation [2].

Biosorption is a biochemical process which occurs naturally when raw, untreated wastewater (WW) is mixed with AS. In this process, particulate and soluble organic matter contained in the WW adsorbs onto the AS flocs [3]. It is hypothesized that EPS contained in the AS have large influence on the biosorption process because of the crucial role that they play in the biosorption of heavy metals [4], and because it has been shown that properties of the sludge have a larger influence on the biosorption than WW properties [3]. Given the "sticky" nature of EPS, it is assumed here that a higher EPS concentration within the AS leads to more biosorption.

2. Materials and Methods

WW and AS were sampled no more than two hours before use and stored at room temperature during transport. Samples were taken at four different wastewater treatment plants (WWTPs) on the island of O'ahu with varying treatment methods and design capacities. Honouliuli WWTP in Ewa Beach uses a trickling filter and solid contact process with a design capacity of 38 million gallons per day (mgpd). Wahiawa WWTP utilizes a membrane bioreactor (MBR) and is designed to treat up to 2.49 mgpd. East Honolulu WWTP in Hawaii Kai and Waimanalo WWTP are both conventional activated sludge plants with design capacities of 5.2 and 0.6 mgpd, respectively.

The cation exchange resin (CER) method [5] was used to extract EPS from each AS, and extractions were run for 0.75, 4, and 24 hours. The CER method was selected due to its ubiquity in literature and its relatively high yields compared to other extraction methods (see Supplementary Document 2.b).

The extracted EPS were measured using mostly colorimetric methods (see Supplementary Document 4) according to wastewater literature [6] and specific EPS literature [7] for concentrations of proteins [8], carbohydrates [9], humic acids [5], DNA using a Qubit 4 Fluorometer, uronic acids [10], and lipids [11]. See Supplementary Documents 1.b.i-iv for SOPs.

The biosorption and Lab DAF experiments were conducted in accordance with previous studies [12]. tCOD, sCOD, ffCOD, and TSS were measured based on Standard Methods [13] according to previous studies [12]. Total dissolved solids (TDS) were measured using Standard Method 2540C [13]. Volatile dissolved solids (VDS) were measured using Standard Method 2540E [13]. Normalized biosorption and kCOD were calculated according to previous studies [12].

3. Results and Discussion

3.1. EPS

500 milliliters (ml) of AS yielded between 200 and 450 ml of settled AS depending on the WWTP from which it was sampled. It was observed that between the four WWTPs, settleability was inversely proportional to the TSS concentration of the unsettled AS. 50 ml of settled AS were used in the CER extraction method, which yielded approximately 40 ml of a yellowish, clear liquid made up of extraction buffer and EPS in liquid form. All units here are in terms of milligrams per liter [mg l^{-1}] of this liquid. A master table containing results of all EPS experiments can be found in Supplementary Document 2.c.

The lipids assay proved not accurate enough for the small concentrations of lipids contained in the extracted EPS, therefore lipids concentrations were assumed to be negligible as other literature has assumed before [14]. The sum of the concentrations of the other measured fractions, namely proteins, carbohydrates, humic acids, DNA, and uronic acids, was therefore assumed as the total EPS concentration. 45 minutes of CER extraction yielded on average 176.47 mg l^{-1} of total EPS when AS from Wahiawa WWTP was used, and between 314.43 and 379.07 mg l^{-1} when AS from one of the other three WWTPs was used (see Supplementary Document 3.b.i). It is unknown why Wahiawa WWTP showed significantly lower total EPS concentrations than the other three treatment plans, but this may be part of the nature of an MBR plant. Further experiments with other MBR plants should be conducted for verification.

With EPS from all plants, proteins, carbohydrates, and humic acids made up most of the total EPS, while DNA and uronic acids constituted minor fractions. This is in agreement with other literature [7]. It was found that ratios between the EPS fractions are relatively consistent between different samples of the same plant, and that 4 and 24 hours of extraction yields similar ratios, while 45 minutes of extraction leads to slightly different ratios. It appears that protein extraction occurs relatively early, while humic acids are extracted relatively late (see Supplementary Document 3.b.ii). With EPS from all plants, proteins, carbohydrates, and humic acids made up most of the total EPS, while DNA and uronic acids constituted minor fractions. This is in agreement with other literature [7]. It was found that ratios between the EPS fractions are relatively consistent between different samples of the same plant, and that 4 and 24 hours of extraction yields similar ratios, while 45 minutes of extraction leads to slightly different ratios. It appears that protein extraction occurs relatively early, while humic acids are extracted relatively late (see Supplementary Document 3.b.ii).

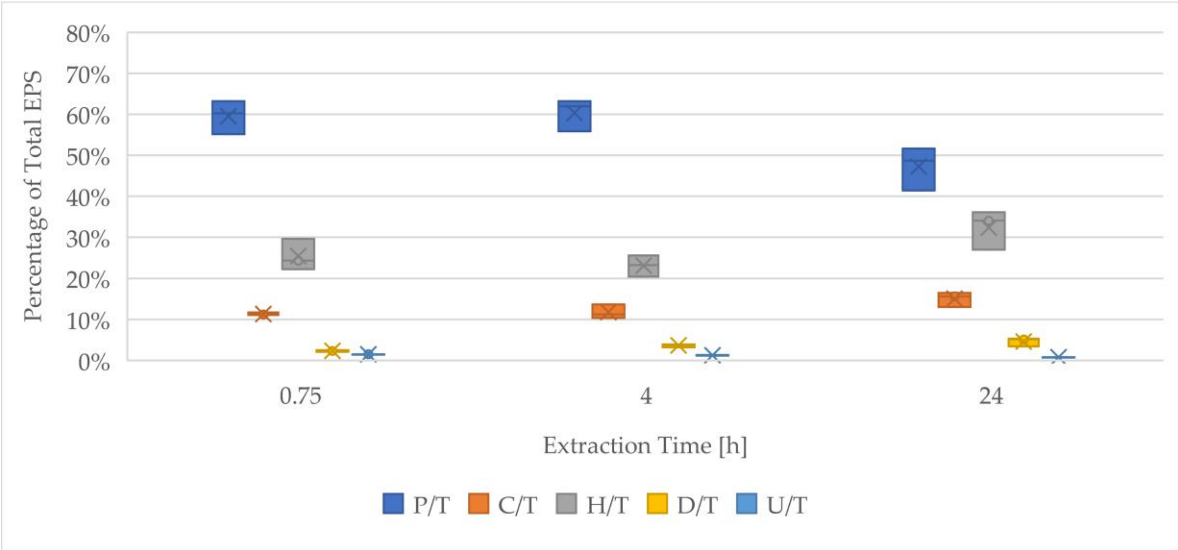


Figure 1. EPS Ratios for AS from Waimanalo WWTP

Literature is not in agreement on how total EPS and therefore the effectiveness of the fractionization of EPS should be measured. While some have proposed using lyophilization [7], others have used COD [3]. It was found here that the results of lyophilization were comparable to the concentrations measured as TDS, usually approximately five times as high as the total EPS concentration. VDS concentrations, however, were found to be always slightly higher than the total EPS, and were therefore chosen to calculate the identification percentage:

$$Identification\ Percentage\ = \frac{Total\ EPS\ [mg\ l^{-1}]}{VDS\ [mg\ l^{-1}]} \tag{1}$$

It was found that while the identification percentages for Waimanalo WWTP and East Honolulu WWTP were above 80 per cent regardless of the extraction duration, the Wahiawa WWTP and Honouliuli WWTP only reached that threshold for extraction times of four hours and above (see Figures 1 and 2). The 4-hour and 24-hour extractions are better suited for analysis due to their relatively high identification percentages and more consistent EPS fraction-to-fraction ratios.

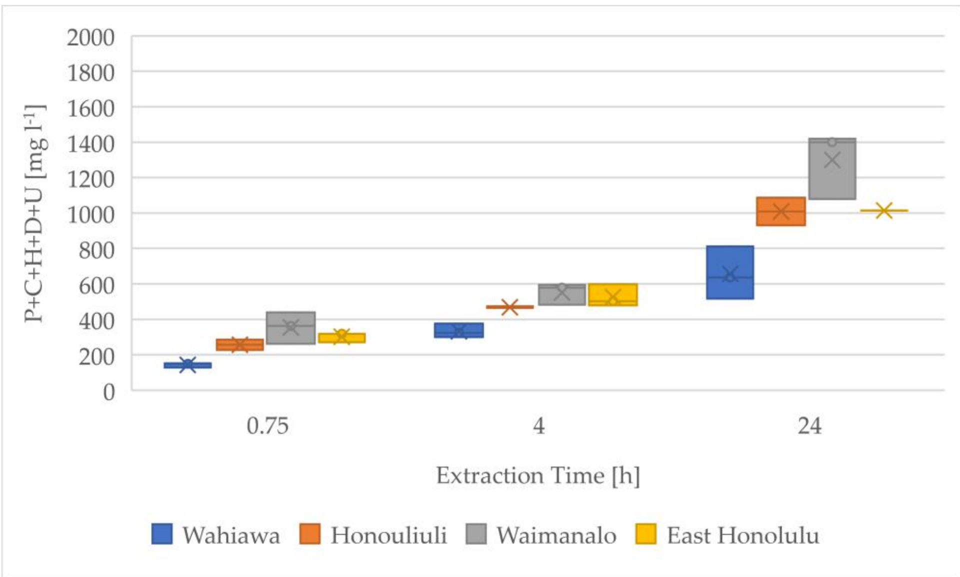


Figure 2. Comparison of Total EPS Concentrations after Different Extraction Times

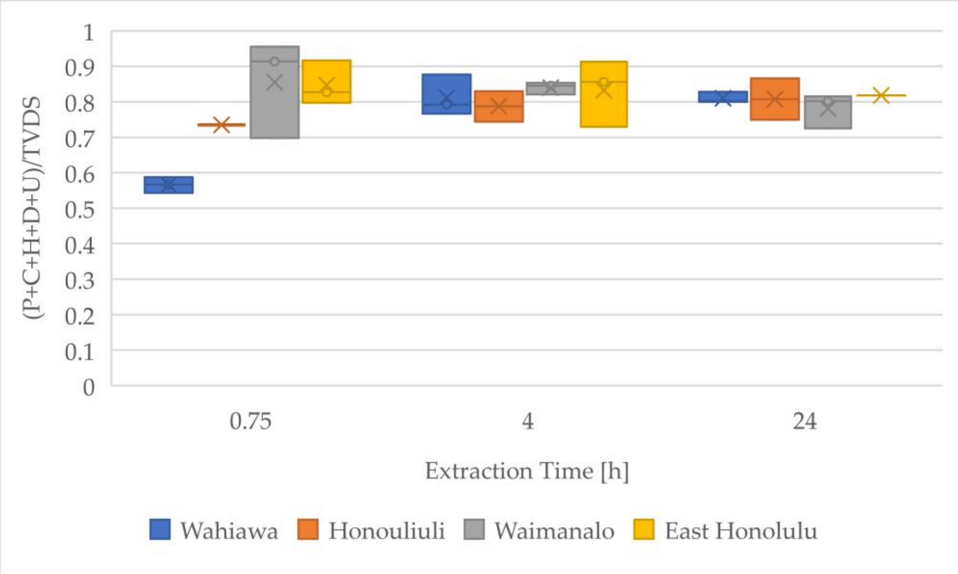


Figure 3. Comparison of Identification Percentages after Different Extraction Times

3.2. Correlation

When using sludge from Waimanalo WWTP and an AS mixing ratio of five per cent (MX5), several correlations between soluble COD removal and EPS concentrations was found (see Figure 3). Waimanalo sludge was selected due to the high identification percentage at 45 minutes of contact time, and MX5 was chosen due to its similarity to real WWTP mixing ratios. It was found that at ANOVA Significance F levels of 0.05 and below there is a positive correlation between normalized sCOD removal and total EPS concentration as well as protein and humic acid concentration (see Table 1). Carbohydrate, uronic acid and DNA concentration also showed a positive correlation to sCOD removal, but not at statistically significant levels. This means that more biosorption of soluble COD takes place the more EPS, especially protein and humic acids, are present. This is in agreement with other literature that found an increase in biosorption when more EPS were present [3].

A statistically significant positive correlation was also found between normalized ffCOD removal and the ratio of uronic acids to total EPS (see Supplementary Document 3biii). Furthermore, statistically significant correlations were found between normalized kCOD removal and the ratio of humic acids to total EPS and carbohydrates (positive) and the ratio of DNA to total EPS (negative) (see Supplementary Document 3biii).

Table 1. Correlation of Normalized Removals with EPS Concentrations, n=4

	Correlation with	**Positive or Negative**	**r^2**	**ANOVA Significance F**
sCOD	Protein	Positive	0.9356	0.0327
sCOD	Humic Acid	Positive	0.9046	0.0489
sCOD	Total EPS	Positive	0.9134	0.0443
ffCOD	Uronic Acid/Total	Positive	0.9303	0.0355
kCOD	Humic Acid/Total	Positive	0.9043	0.0491
kCOD	DNA/Total	Negative	0.9369	0.0321
kCOD	Humic Acid/Carbohydrates	Positive	0.9538	0.0224

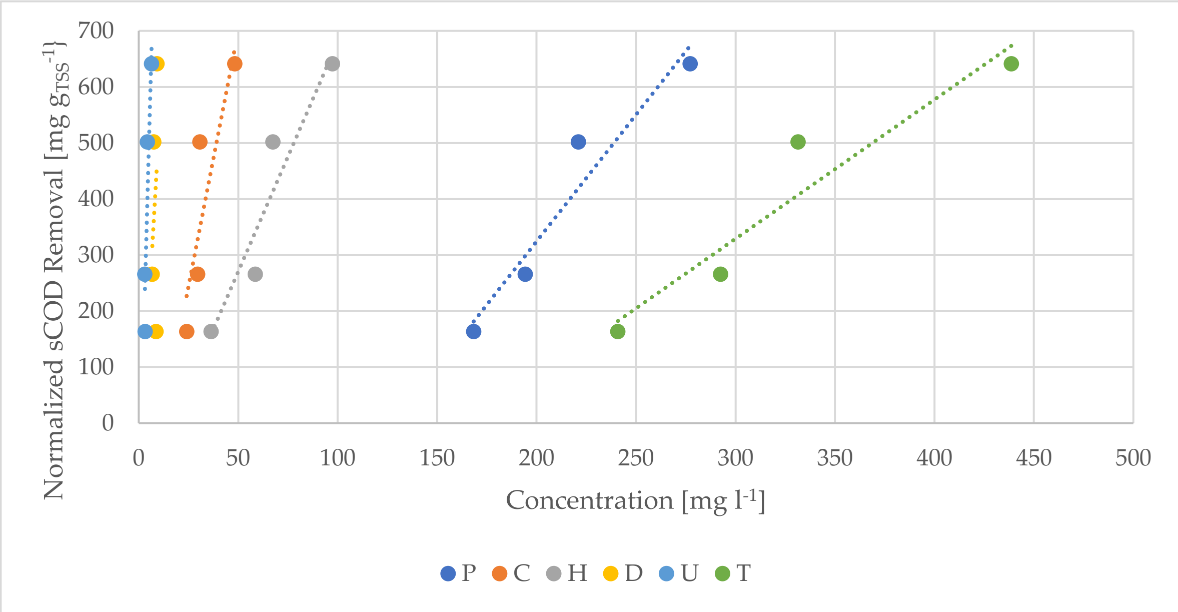


Figure 4. Correlation of Normalized sCOD Removal with EPS Concentrations

3.3. Mass Balance

It is assumed that WW and Lab DAF effluent ("DAF") do not contain relevant amounts of EPS other than in the form of SMP, and that AS and Float contain negligible amounts of SMP. In order to find a mass balance of extracellular polymeric substances for the biosorption experiment, the following equation was used:

$$\frac{4.5 \times WW + 0.5 \times {}^{AS}/_{2.4}}{5} = \frac{0.97 \times DAF + 0.03 \times Float}{0.85} \qquad (2)$$

This equation is applicable for any concentrations measured of the four components, WW, AS, DAF, and Float, the former forming the educts, and the latter being the products. The AS component is divided by 2.4 because this was found to be the TSS ratio between unsettled AS, which was used in the biosorption experiment, and settled AS, which was used for CER extraction and therefore measurements. It was found that the sum of educt and product EPS were 101.67 and 103.70 mg l^{-1}, respectively (see Figure 3). Given that the total EPS of biosorption educts and products were almost identical, it can be assumed that hardly any absorption of EPS into the cells took place during the experiment. While the sCOD of the DAF shows a 26.7 per cent removal compared to the WW, the total VDS was reduced by 31.4 per cent, and the total EPS was reduced by 13.1 per cent. The sCOD removal observed in the mass balance experiment was very similar to the VDS removal which has been shown to be similar to the total EPS removal at higher extraction times. This allows the assumption that, during biosorption, the removed sCOD is made up of mostly EPS. The WW contains a higher combined protein concentration than the DAF, while the opposite is the case for the humic acid concentrations. It is assumed that protein was strongly adsorbed onto the AS flocs, while humic acids were partly desorbed (see Figure 4).

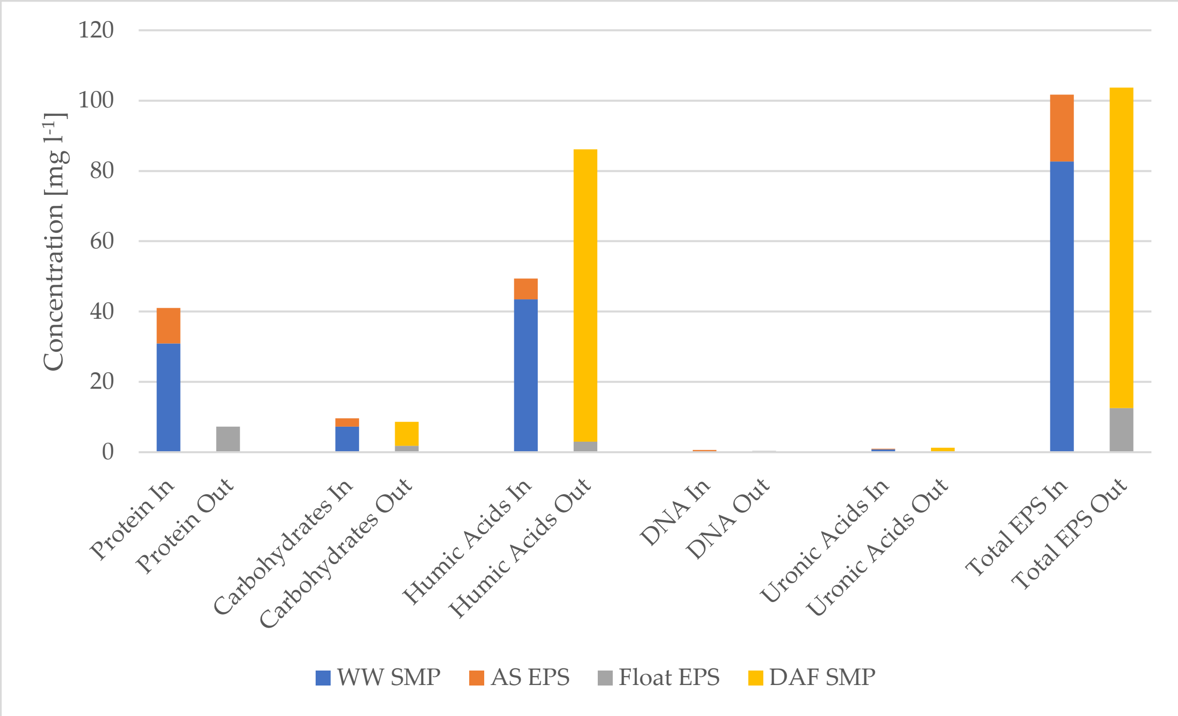


Figure 5. Mass Balance of Biosorption Experiment EPS

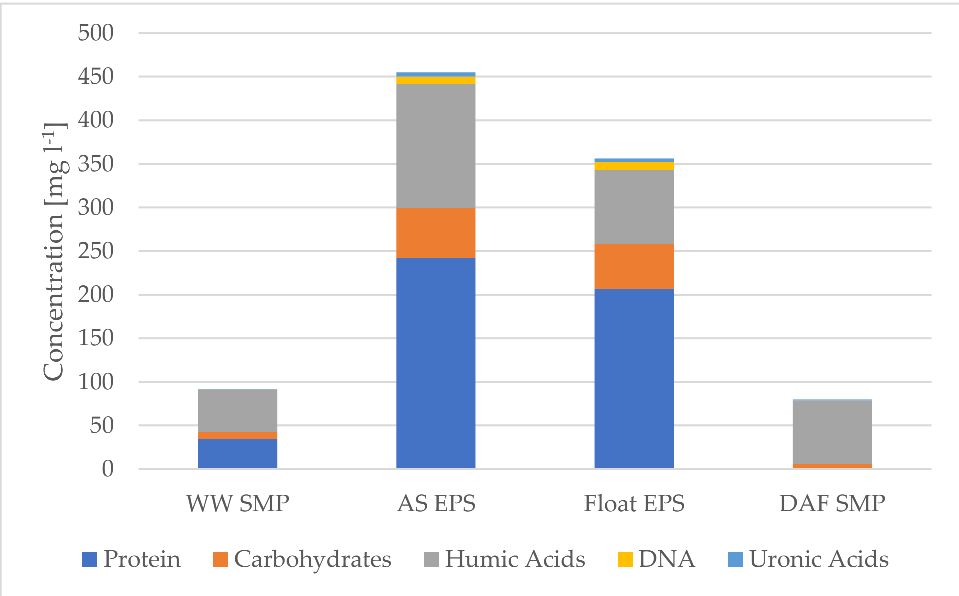


Figure 6. EPS Composition of Biosorption Experiment Products and Educts

4. Conclusions

The assumption that a higher total AS EPS concentration leads to higher sCOD removals during biosorption has been confirmed. Most of the sCOD removed during biosorption is assumed to be EPS, specifically protein. Extraction times of four or more hours are encouraged to produce comprehensive results due to higher identification ratios. Protein appears to be extracted later and humic acids earlier.

Funding: This research received funding from R.M. Towill.

References

1. Sheng, G.P., H.Q. Yu, and X.Y. Li, *Extracellular polymeric substances (EPS) of microbial aggregates in biological wastewater treatment systems: a review.* Biotechnol Adv, 2010. **28**(6): p. 882-94.
2. *Microbial Extracellular Polymeric Substances*. 1 ed. 1999, Germany: Springer. 258.
3. F. Jorand, J.C.B., P. Palmgren, Ph. Nielsen, V. Urbain, J. Manem, *Biosorption of wastewater organics by activated sludges.* 1995.
4. Comte, S., G. Guibaud, and M. Baudu, *Biosorption properties of extracellular polymeric substances (EPS) resulting from activated sludge according to their type: Soluble or bound.* Process Biochemistry, 2006. **41**(4): p. 815-823.
5. B. Frolund, T.G., P. H. Nielsen, *Enzymatic activity in the activated-sludge floc matrix.* Applied Microbiology and Biotechnology, 1995. **43**: p. 755-761.
6. Kamma Raunkjaer, T.H.-J., Per Halkhaer-Nielsen, *Measurement of Pools of Protein, Carbohydrate and Lipid in Domestic Wastewater.* Water Research, 1994. **28**(2): p. 251-262.
7. Hong Liu, H.H.P.F., *Extraction of extracellular polymeric substances (EPS) of sludges.* Journal of Biotechnology, 2002. **95**: p. 249-256.
8. Jaap Waterborg, H.M., *The Lowry Method for Protein Quantitation.* Methods in Molecular Biology, 1984. **1**: p. 1-3.
9. Gaudy, A.F., *Colorimetric Determination of Protein and Carbohydrate.* Industrial Water & Wastes, 1962: p. 17-22.
10. Paul K. Kintner III, J.P.v.B., *Carbohydrate Interference and Its Correction in Pectin Analysis Using the m-Hydroxydiphenyl Method.* Journal of Food Science, 1982. **47**: p. 756-759.
11. Christopher S. Frings, R.T.D., *Improved Determination of Total Serum Lipids by the Sulfo-Phospho-Vanillin Reaction.* Clinical Chemistry, 1972. **18**(7): p. 673-674.
12. Joachim Schneider, R.B.J., Tiow-Ping Wong, Bing Hu, *Effects of Mixing Ratio, Contact Time, and DO on Efficiency of Biosorption for Primary Carbon Diversion.* 2019.
13. *Standard Methods for the Examination of Water and Wastewater*. 20th ed. 1999: APHA. 1325.
14. D'Abzac, P., et al., *Extraction of extracellular polymeric substances (EPS) from anaerobic granular sludges: comparison of chemical and physical extraction protocols.* Appl Microbiol Biotechnol, 2010. **85**(5): p. 1589-99.

Supplementary Documents

1. SOPs
    a. EPS Extraction
        i. CER
    b. Characterization
        i. Carbohydrates
        ii. Proteins/Humic Acids
        iii. Uronic Acids
        iv. Lipids
2. Data Tables
    a. Biosorption Master
    b. EPS Extraction Efficiencies
    c. EPS Master
3. Graphs
    a. Paper A
        i. DO Concentration
        ii. Mixing Ratios
        iii. Isotherm
        iv. Separation
        v. No Biosorption
    b. Paper B
        i. 45min Extraction Totals
        ii. EPS Ratios
        iii. Correlation
4. Photos

SOP: Cation Exchange Resin (CER)

Materials & Equipment [1]

Chemicals:
- -Monosodium phosphate (NaH_2PO_4)
- -Trisodium phosphate (Na_3PO_4)
- -Sodium chloride (NaCl)
- -Potassium chloride (KCl)
- -Cation Exchange Resin, DOWEX 50 × 8, 20-50 mesh in sodium form

Apparatus:
- -100ml & 50ml beaker
- -Centrifuge & 5 cups
- -Stir plate & mag-bar
- -500ml brown bottle for buffer
- -Scale & weighing paper cut into 4 pieces

Method [1]

1. Mix 2mM Na_3PO_4, 4 mM NaH_2PO_4, 9 mM NaCl and 1 mM KCl at pH7 in brown bottle, label "Buffer"
   (for 500ml: 0.1639g Na_3PO_4, 0.2400g NaH_2PO_4, 0.2630g NaCl, 0.0373g KCl, 500ml water)
2. In 100ml beaker, wash CER in Buffer for 1h
   (for 50ml sample @ 3 g-VS/l, 70g-CER/g-VS: 10.5g CER, submerge in Buffer to total volume 20ml, let sit)
3. Settle sample for 1.5 hours at 4°C in sample bottle, decant supernatant, transfer to centrifuge cup
   (500ml of WAS, decant approximately 420ml, transfer 50ml)
4. Centrifuge sample at 2000g for 15min at 4°C, decant supernatant
5. Add pellet to 100ml beaker, suspend to previous volume using Buffer
   (60.5ml total, accounting for CER)
6. Stir for 45min/4h/24h at 600 rpm at 4°C
   (in fridge, mag-bar stir plate at second lowest setting)
7. Centrifuge sample/CER mixture at 12000g for 2min at 4°C to remove CER, capture supernatant
8. Centrifuge supernatant twice for 15min at 12000g at 4°C, capture supernatant, change cups in between
9. Transfer supernatant to 50ml beaker

References

1. B. Frolund, P.N., R. Palmgren, K. Keiding, *Extraction of Extracellular Polymers from Activated Sludge Using a Cation Exchange Resin.* Water Ressources, 1996. **30**(8): p. 1749-1758.

SOP: EPS Characterization – Carbohydrates

Materials & Equipment [1]

Chemicals:
- -Anthrone
- -95% Sulfuric acid (H_2SO_4)
- -Glucose/Dextrose
- -Deionized water (H_2O)

Apparatus:
- -Vials
- -Spectrophotometer
- -Digestion block
- -Fridge
- -2x 200ml beaker
- -Pipette & tips
- -Scale & weighing paper

Procedure [1]

1. 2h before use, dissolve 40mg of anthrone in 20ml of 95% H_2SO_4, bring to 4°C in fridge, label "Reagent"
2. Add 10mg Glucose to 100ml H_2O, label "Solution (100 mg/l)"
3. Add the following to individual vials and store until ice cold, also store 100ml water in fridge:
    a. 2.5ml extracted EPS liquid, label "Sample"
    b. 2.5ml H_2O, label "Blank"
    c. 1.5ml Solution, + 1ml H_2O, label "Standard (60 mg/l)"
4. Add 5ml of Reagent to each vial and shake thoroughly
5. Place all vials in a digestion block at 100°C for 15min
6. Place all vials in the cold water in the fridge until they reach room temperature
7. Read absorbance at 620nm, use Blank to zero, create standard curve, calculate sample concentration

Reference

1. Gaudy, A.F., *Colorimetric Determination of Protein and Carbohydrate.* Industrial Water & Wastes, 1962: p. 17-22.

SOP: EPS Characterization – Protein & Humic Acids

Materials & Equipment [1], [2]

Chemicals:
- -Sodium carbonate (Na_2CO_3)
- -Copper sulfate ($CuSO_4$)
- -Potassium sodium tartrate (PST)
- -Sodium hydroxide (NaOH)
- -Folin reagent (FR)
- -Bovine serum albumin, 50 mg/ml (BSA)
- -Humic Acid
- -Deionized water (H_2O)

Apparatus:
- -Spectrophotometer
- -Digestion block
- -2x 100ml beaker
- -50ml beaker
- -Pipette & tips
- -Vials
- -Scale & weighing paper
- -Fridge
- -Brown bottle

Solutions [1], [2]

1. Mix the following in a 100ml beaker, label “CFR Total”
   a. 50ml H_2O
   b. 1g Na_2CO_3
   c. 5mg $CuSO_4$
   d. 10mg PST
2. Repeat step 1, omitting $CuSO_4$, label “CFR Blind”
3. Mix 0.8g NaOH with 9.2ml distilled water, label “NaOH Solution (2N)”
   (for 500ml: 40g NaOH, 500ml H_2O, store in brown bottle)
4. Mix 0.03ml of 50 mg/ml BSA with 1.47ml H_2O, label “BSA (1000 mg/l)”, store in freezer
5. Dilute 0.7ml of 1000 mg/l BSA with 0.35ml H_2O, label “Protein Solution (666 mg/l)”
6. Mix 10mg of humic acid with 50ml H_2O, label “Humic Acid Solution (200 mg/l)”
7. Add the following to two (2) individual vials each
   a. 0.5ml extracted EPS, label “Sample”
   b. 0.5ml H_2O, label “Blank”
   c. 0.5ml Protein Solution, label “Prot 666 mg/l”

   d. 0.5ml Humic Acid Solution, label "Humic 200 mg/l"
8. Add 0.5ml NaOH Solution to each vial, place in digestion block for 10min at 100°C
9. Cool vials to room temperature in fridge, add 5ml of CFR, let stand at room temperature for 10min
10. Add 0.5ml FR and shake vigorously, let mixture stand at room temperature for 45min
11. Read absorbance A_{total} (where CFR Total was added) at 750nm
12. Read absorbance A_{Blind} (where CFR Blind was added) at 750nm

Protein & Humic absorbance [2]

- $A_{protein} = 1.25 * (A_{total} - A_{blind})$
- $A_{humic} = A_{blind} - 0.2 * A_{protein} = 1.25 * A_{Blind} - 0.25 * A_{Total}$

References

1. Jaap Waterborg, H.M., *The Lowry Method for Protein Quantitation.* Methods in Molecular Biology, 1984. **1**: p. 1-3.
2. B. Frolund, T.G., P. H. Nielsen, *Enzymatic activity in the activated-sludge floc matrix.* Applied Microbiology and Biotechnology, 1995. **43**: p. 755-761.

SOP: EPS Characterization – Uronic Acids

Materials & Equipment [1]

Chemicals:
- -Sodium tetraborate (Borax)
- -Sulfuric acid (H_2SO_4)
- -m-Hydroxydiphenyl (3-Phenylphenol)
- -Sodium hydroxide (NaOH)
- -Glucuronic acid
- -Distilled water (H_2O)

Method [1]

1. Mix 0.1668g Borax with 35ml H_2SO_4, label "0.0125M Sulfuric acid/tetraborate (SATB)"
2. Mix 0.5g NaOH with 100ml H_2O in brown bottle, label "NaOH (0.5%)"
3. Mix 0.15g m-Hydroxydiphenyl, 0.5g NaOH with 100ml H_2O in brown bottle, label "m-Hydroxydiphenyl solution (mH)", keep in fridge
4. Add 10mg Glucuronic Acid to 40ml H_2O, label "Standard (250 mg/l)", keep in fridge for up to 1 month
5. Add the following to individual tubes and put into cold water
    a. 0.2ml Standard + 0.8ml H_2O, label "Uronic (50 mg/l)" (x2)
    b. 1ml EPS, label "EPS" (x2)
    c. 1ml H_2O, label "Blank"
6. After allowing to cool for 5min, add 6ml of SATB to each tube and shake thoroughly
7. Heat tubes in a digestion block at 100°C for 5min, then immediately place in ice-water bath for 5min
8. Add 0.1ml of mH to one Standard tube and one EPS tube, and 0.1ml of 0.5% NaOH to all others
9. Shake thoroughly and let sit for 20min at room temperature
10. Zero Spectrophotometer using Blank then measure absorbances A_{total} at 520nm
11. Subtract A_{blank} (where NaOH was added) from A_{total} (where mH was added) for corrected absorbance

Reference

1. Paul K. Kintner III, J.P.v.B., *Carbohydrate Interference and Its Correction in Pectin Analysis Using the m-Hydroxydiphenyl Method*. Journal of Food Science, 1982. **47**: p. 756-759.

SOP: EPS Characterization – Lipids

Materials & Equipment [1]

Chemicals	-Vanillin -Phosphoric acid (H_3PO_4) -Olive oil (standard) -Ethanol -Sulfuric acid (H_2SO_4) -Water (H_2O)
Apparatus	-Spectrophotometer & tubes -1l brown bottle -40ml glass bottle -Digestion block -Water bath

Method [1]

1. Dissolve 0.42g vanillin in 70ml H_2O, label "Vanillin Reagent (6 g/l)"
2. Combine 70ml Vanillin Reagent and 10ml water, add 120ml concentrated H_3PO_4 with constant stirring
3. Label "Phospho-Vanillin Reagent (PVR)", store for up to 2 months in brown bottle at room temperature
4. Combine 0.11ml olive oil and 20ml ethanol, mix well
5. Label "Olive Oil Solution (6 g/l)", store for up to 1 month in the fridge
6. Add 0.1ml concentrated H_2SO_4 to each tube
7. Add the following to individual tubes and shake well
    a. 0.01ml H_2O, label "Blank"
    b. 0.01ml EPS, label "Sample"
    c. 0.01ml Solution, label "Standard (6000 mg/l)"
8. Place all tubes in digestion block for 10min at 100°C, then cool them in cold water for 5min
9. Add 5ml of PVR to each tube, shake well, then incubate at 37°C in water bath for 15min
10. Cool tubes in cold water for 5min, measure absorbance at 540nm within 30min

Reference

1. Christopher S. Frings, R.T.D., *Improved Determination of Total Serum Lipids by the Sulfo-Phospho-Vanillin Reaction.* Clinical Chemistry, 1972. **18**(7): p. 673-674.

Date	WWTP	Sample	DO [mg/l]	AS %	Total COD [mg/l]	sCOD [mg/l]	ffCOD [mg/l]	kCOD [mg/l]	TSS [mg/l]	Normalized sCOD Removal [mg-sCOD/g-TSS]	Normalized ffCOD Removal [mg-ffCOD/g-TSS]	Normalized kCOD Removal [mg-kCOD/g-TSS]
Dec-18	Honouliuli	WAS S100	N/A	N/A	246	60	62	-2	310	N/A	N/A	N/A
Dec-18	Honouliuli	WW S100	N/A	N/A	258	130	76	54	66.66666667	N/A	N/A	N/A
Dec-18	Honouliuli	Post-Biosorption S100	1.0	10%	523	91	72	19	275.6756757	112.8	93.6	19.2
Dec-18	Honouliuli	WAS S200	N/A	N/A	2480	68	64	4	1780	N/A	N/A	N/A
Dec-18	Honouliuli	WW S200	N/A	N/A	291	151	110	41	75.51020408	N/A	N/A	N/A
Dec-18	Honouliuli	WAS S300	N/A	N/A	3252	75	69	6	2260	N/A	N/A	N/A
Dec-18	Honouliuli	WW S300	N/A	N/A	291	148	97	51	82.60869565	N/A	N/A	N/A
Dec-18	Honouliuli	WW	N/A	N/A	385	138	111	27	185	N/A	N/A	N/A
Dec-18	Honouliuli	Post-Biosorption	1.0	10%	867	100	89	11	482.6086957	91.2	52.8	38.4
Dec-18	Honouliuli	WAS	N/A	N/A	N/D	67	57	10	3750	N/A	N/A	N/A
Dec-18	Honouliuli	Post-Biosorption S300	1.0	10%	679	93	84	9	363.8888889	108	64.8	43.2
Dec-18	Honouliuli	Lab DAF	1.0	10%	222.3529412	116.4705882	89.41176471	27.05882353	78.43137255	51.67058824	51.81176471	-0.141176471
21-Jan-19	Honouliuli	Post-Biosorption S100	1.0	10%	191	101	83	18	47.5	262.1167883	110.3649635	151.7518248
21-Jan-19	Honouliuli	WW PS100	N/A	N/A	221	135	130	5	32.5	N/A	N/A	N/A
21-Jan-19	Honouliuli	WW S100	N/A	N/A	246	153	98	55	52.5	N/A	N/A	N/A
21-Jan-19	Honouliuli	Post-Biosorption PS200	1.0	10%	183	95	92	3	45	289.7080292	68.97810219	220.729927
21-Jan-19	Honouliuli	WW PS200	N/A	N/A	226	128	119	9	45	N/A	N/A	N/A
21-Jan-19	Honouliuli	WW S200	N/A	N/A	327	155	101	54	85	N/A	N/A	N/A
21-Jan-19	Honouliuli	WW PS300	N/A	N/A	264	132	113	19	55	N/A	N/A	N/A
21-Jan-19	Honouliuli	WW S300	N/A	N/A	325	152	114	38	87.5	N/A	N/A	N/A
21-Jan-19	Honouliuli	Post-Biosorption S200	1.0	10%	382	101	80	21	167.5	262.1167883	124.1605839	137.9562044
21-Jan-19	Honouliuli	WW	N/A	N/A	546	158	107	51	155	N/A	N/A	N/A
21-Jan-19	Honouliuli	Post-Biosorption	1.0	10%	680	115	83	32	312.5	197.7372263	110.3649635	87.37226277
21-Jan-19	Honouliuli	Post-Biosorption PS300	1.0	10%	197	96	87	9	50	285.1094891	91.97080292	193.1386861
21-Jan-19	Honouliuli	WAS	N/A	N/A	N/D	65	56	9	1957.142857	N/A	N/A	N/A
21-Jan-19	Honouliuli	Post-Biosorption S300	1.0	10%	449	98	90	8	195	275.9124088	78.17518248	197.7372263
21-Jan-19	Honouliuli	Lab DAF	1.0	10%	281.1764706	128.2352941	78.82352941	49.41176471	108.8235294	136.8741949	129.5706312	7.303563761
21-Jan-19	Honouliuli	WWTP DAF	1.0	10%	257	97	70	27	90	280.5109489	170.1459854	110.3649635
25-Jan-19	Honouliuli	Post-Biosorption PS200	1.0	10%	N/D	92	77	15	67.5	219.3377483	64.37956204	154.9581863
25-Jan-19	Honouliuli	Post-Biosorption S200	1.0	10%	343	88	75	13	170	238.410596	73.57664234	164.8339537
25-Jan-19	Honouliuli	WW PS200	N/A	N/A	191	113	93	20	45	N/A	N/A	N/A
25-Jan-19	Honouliuli	WW S200	N/A	N/A	289	123	91	32	82.5	N/A	N/A	N/A
25-Jan-19	Honouliuli	Post-Biosorption PS300	1.0	10%	174	93	79	14	70	214.5695364	55.18248175	159.3870547
25-Jan-19	Honouliuli	WW PS300	N/A	N/A	182	110	97	13	45	N/A	N/A	N/A
25-Jan-19	Honouliuli	WW S300	N/A	N/A	299	123	95	28	97.5	N/A	N/A	N/A
25-Jan-19	Honouliuli	WW	N/A	N/A	466	138	91	47	152.5	N/A	N/A	N/A
25-Jan-19	Honouliuli	Post-Biosorption S300	1.0	10%	480	92	68	24	227.5	219.3377483	105.7664234	113.571325
25-Jan-19	Honouliuli	Post-Biosorption	1.0	10%	670	105	85	20	350	157.3509934	27.59124088	129.7597525
25-Jan-19	Honouliuli	WAS	N/A	N/A	N/D	68	66	2	1887.5	N/A	N/A	N/A
25-Jan-19	Honouliuli	Lab DAF	1.0	10%	245.8823529	102.3529412	84.70588235	17.64705882	117.6470588	169.9727308	28.94375268	141.0289781
25-Jan-19	Honouliuli	WWTP DAF	1.0	10%	195	101	82	19	102.5	176.4238411	41.38686131	135.0369797
25-Jan-19	Honouliuli	WWTP PDAF	1.0	10%	133	84	69	15	65	257.4834437	101.1678832	156.3155605
28-Jan-19	Honouliuli	Post-Biosorption PS200	1.0	10%	185	98	88	10	90	123.5820896	128.7591241	-5.177034535
28-Jan-19	Honouliuli	Post-Biosorption S200	1.0	10%	487	109	86	23	262.5	94.02985075	137.9562044	-43.92635363
28-Jan-19	Honouliuli	Post-Biosorption PS300	1.0	10%	188	102	84	18	100	112.8358209	147.1532847	-34.31746378
28-Jan-19	Honouliuli	Post-Biosorption S300	1.0	10%	548	103	86	17	297.5	110.1492537	137.9562044	-27.80695065
28-Jan-19	Honouliuli	WW PS200	N/A	N/A	202	110	99	11	65	N/A	N/A	N/A
28-Jan-19	Honouliuli	WW S200	N/A	N/A	306	142	107	35	85	N/A	N/A	N/A
28-Jan-19	Honouliuli	WW PS300	N/A	N/A	207	116	110	6	65	N/A	N/A	N/A
28-Jan-19	Honouliuli	WW S300	N/A	N/A	333	140	110	30	97.5	N/A	N/A	N/A
28-Jan-19	Honouliuli	WW	N/A	N/A	421	144	116	28	142.5	N/A	N/A	N/A
28-Jan-19	Honouliuli	Post-Biosorption	1.0	10%	824	111	103	8	417.5	88.65671642	59.7810219	28.87569452
28-Jan-19	Honouliuli	WAS	N/A	N/A	N/D	74	62	12	3350	N/A	N/A	N/A
28-Jan-19	Honouliuli	Lab DAF	1.0	10%	232.9411765	117.6470588	101.1764706	16.47058824	120.5882353	70.79894644	68.16659511	2.632351339
28-Jan-19	Honouliuli	WWTP DAF	1.0	10%	261	113	81	32	135	83.28358209	160.9489051	-77.66532302
30-Jan-19	Honouliuli	WW S4750	N/A	N/A	393	119	90	29	157.5	N/A	N/A	N/A
30-Jan-19	Honouliuli	WW Lab DAF	N/A	N/A	222.3529412	124.7058824	118.8235294	5.882352941	58.82352941	N/A	N/A	N/A
30-Jan-19	Honouliuli	WW	N/A	N/A	537	133	109	24	147.5	N/A	N/A	N/A
30-Jan-19	Honouliuli	WW WWTP DAF	N/A	N/A	203	112	78	34	50	N/A	N/A	N/A
7-Feb-19	Honouliuli	WW S4750	N/A	N/A	480	150	120	30	160	N/A	N/A	N/A
7-Feb-19	Honouliuli	WW	N/A	N/A	439	155	97	58	170	N/A	N/A	N/A
7-Feb-19	Honouliuli	Post-Biosorption	1.0	10%	555	96	81	15	520	403.56	109.44	294.12
7-Feb-19	Honouliuli	Lab DAF	1.0	10%	268.2352941	123.5294118	87.05882353	36.47058824	94.11764706	215.2588235	67.99764706	147.2611765

Date	WWTP	Sample	DO [mg/l]	AS %	Total COD [mg/l]	sCOD [mg/l]	ffCOD [mg/l]	kCOD [mg/l]	TSS [mg/l]	Normalized sCOD Removal [mg-sCOD/g-TSS]	Normalized ffCOD Removal [mg-ffCOD/g-TSS]	Normalized kCOD Removal [mg-kCOD/g-TSS]
7-Feb-19	Honouliuli	WAS	N/A	N/A	N/D	72	55	17	1315.789474	N/A	N/A	N/A
7-Feb-19	Honouliuli	WWTP DAF	1.0	10%	236	108	93	15	72.5	321.48	27.36	294.12
7-Feb-19	Honouliuli	WWTP PDAF	1.0	10%	173	114	85	29	42.5	280.44	82.08	198.36
27-Mar-19	Honouliuli	Lab DAF	1.0	5%	285.8823529	90.58823529	84.70588235	5.882352941	102.9411765	195.3295207	102.4509804	92.87854031
27-Mar-19	Honouliuli	WW	N/A	N/A	366	135	108	27	135	N/A	N/A	N/A
27-Mar-19	Honouliuli	Post-Biosorption (not centrifuged)	1.0	5%	667	92	72	20	317.5	189.1203704	158.3333333	30.78703704
27-Mar-19	Honouliuli	Post-Biosorption (centrifuged)	1.0	5%	648	96	87	9	N/D	171.5277778	92.36111111	79.16666667
27-Mar-19	Honouliuli	WAS	N/A	N/A	N/D	74	60	14	4320	N/A	N/A	N/A
27-Mar-19	Honouliuli	WWTP DAF	1.0	5%	230	87	74	13	80	211.1111111	149.537037	61.57407407
29-Mar-19	Honouliuli	Lab DAF	0.5	10%	295.2941176	109.4117647	91.76470588	17.64705882	102.9411765	103.6900751	57.65224151	46.03783364
29-Mar-19	Honouliuli	WW	N/A	N/A	423	153	116	37	132.5	N/A	N/A	N/A
29-Mar-19	Honouliuli	Post-Biosorption (not centrifuged)	0.5	10%	921	94	84	10	492.5	140.3524229	76.12334802	64.22907489
29-Mar-19	Honouliuli	Post-Biosorption (centrifuged)	0.5	10%	N/A	110	89	21	N/A	102.2907489	64.22907489	38.06167401
29-Mar-19	Honouliuli	WAS	N/A	N/A	N/D	72	61	11	3783.333333	N/A	N/A	N/A
29-Mar-19	Honouliuli	WWTP DAF	0.5	10%	275	106	96	10	97.5	111.8061674	47.57709251	64.22907489
1-Apr-19	Honouliuli	Lab DAF	0.5	5%	263.5294118	96.47058824	74.11764706	22.35294118	79.41176471	147.5208474	112.4070318	35.11381564
1-Apr-19	Honouliuli	WW	N/A	N/A	440	137	105	32	200	N/A	N/A	N/A
1-Apr-19	Honouliuli	Post-Biosorption (not centrifuged)	0.5	5%	784	95	92	3	370	152.8735632	47.31800766	105.5555556
1-Apr-19	Honouliuli	Post-Biosorption (centrifuged)	0.5	5%	N/A	110	90	20	N/A	98.27586207	54.59770115	43.67816092
1-Apr-19	Honouliuli	WAS	N/A	N/A	N/D	83	74	9	5220	N/A	N/A	N/A
1-Apr-19	Honouliuli	WWTP DAF	0.5	5%	255	92	78	14	72.5	163.7931034	98.27586207	65.51724138
10-Apr-19	Honouliuli	Lab DAF	1.0	10%	257.6470588	85.88235294	N/D	N/D	100	103.7846837	N/D	N/D
10-Apr-19	Honouliuli	WW	N/A	N/A	410	147	112	35	140	N/A	N/A	N/A
10-Apr-19	Honouliuli	Post-Biosorption (not centrifuged)	1.0	10%	1351	82	73	9	675	110.3773585	66.22641509	44.1509434
10-Apr-19	Honouliuli	Post-Biosorption (centrifuged)	1.0	10%	N/A	91	83	8	N/A	95.09433962	49.24528302	45.8490566
10-Apr-19	Honouliuli	WAS	N/A	N/A	N/D	82	81	1	5300	N/A	N/A	N/A
10-Apr-19	Honouliuli	WWTP DAF	1.0	10%	233	80	78	2	90	113.7735849	57.73584906	56.03773585
12-Apr-19	East Honolulu	WAS	N/A	N/A	N/D	100	97	3	4616.666667	N/A	N/A	N/A
12-Apr-19	East Honolulu	WW	N/A	N/A	392	174	154	20	172.5	N/A	N/A	N/A
12-Apr-19	East Honolulu	Post-Biosorption (not centrifuged)	1.0	10%	771	138	N/D	N/D	607.5	70.18050542	N/D	N/D
12-Apr-19	East Honolulu	Post-Biosorption (centrifuged)	1.0	10%	N/D	160	153	7	N/A	27.29241877	1.949458484	25.34296029
12-Apr-19	East Honolulu	WWTP DAF	1.0	10%	206	168	151	17	57.5	11.6967509	5.848375451	5.848375451
12-Apr-19	East Honolulu	Lab DAF	1.0	10%	212.3529412	135.8823529	N/D	N/D	67.64705882	74.30877044	N/D	N/D
17-Apr-19	Honouliuli	WW S180	N/A	N/A	N/D	120	N/D	N/D	65	N/A	N/A	N/A
17-Apr-19	Honouliuli	WW 10PS180	N/A	N/A	N/D	100	N/D	N/D	27.5	N/A	N/A	N/A
17-Apr-19	Honouliuli	WW 2PS180	N/A	N/A	N/D	94	N/D	N/D	52.5	N/A	N/A	N/A
17-Apr-19	Honouliuli	WW 5PS180	N/A	N/A	N/D	90	N/D	N/D	40	N/A	N/A	N/A
17-Apr-19	Honouliuli	WW S300	N/A	N/A	N/D	114	N/D	N/D	82.5	N/A	N/A	N/A
17-Apr-19	Honouliuli	WW 2PS300	N/A	N/A	N/D	107	N/D	N/D	50	N/A	N/A	N/A
17-Apr-19	Honouliuli	WW 10PS300	N/A	N/A	N/D	94	N/D	N/D	32.5	N/A	N/A	N/A
17-Apr-19	Honouliuli	WW 5PS300	N/A	N/A	N/D	94	N/D	N/D	40	N/A	N/A	N/A
17-Apr-19	Honouliuli	WW	N/A	N/A	N/D	104	N/D	N/D	107.5	N/A	N/A	N/A
24-Apr-19	Honouliuli	WW S300 1.5/3.5	N/A	N/A	N/D	149	N/D	N/D	37.5	N/A	N/A	N/A
24-Apr-19	Honouliuli	WW S300 1.5/5	N/A	N/A	N/D	137	N/D	N/D	37.5	N/A	N/A	N/A
24-Apr-19	Honouliuli	WW S300 1.5/7	N/A	N/A	N/D	134	N/D	N/D	37.5	N/A	N/A	N/A
24-Apr-19	Honouliuli	WW S300 3.0/5	N/A	N/A	N/D	133	N/D	N/D	25	N/A	N/A	N/A
24-Apr-19	Honouliuli	WW S300 3.0/3.5	N/A	N/A	N/D	130	N/D	N/D	32.5	N/A	N/A	N/A
24-Apr-19	Honouliuli	WW S300 3.0/7	N/A	N/A	N/D	124	N/D	N/D	30	N/A	N/A	N/A
24-Apr-19	Honouliuli	WW	N/A	N/A	N/D	159	N/D	N/D	77.5	N/A	N/A	N/A
25-Apr-19	East Honolulu	WAS	N/A	N/A	N/D	50	76	-26	5250	N/A	N/A	N/A
25-Apr-19	East Honolulu	WW	N/A	N/A	545	149	132	17	225	N/A	N/A	N/A
25-Apr-19	East Honolulu	Post-Biosorption 1	1.0	5%	814	118	117	1	477.5	112.1904762	54.28571429	57.9047619
25-Apr-19	East Honolulu	Lab DAF 0.5	0.5	5%	281.7647059	130	104.1176471	25.88235294	114.7058824	68.76190476	100.907563	-32.14565826
25-Apr-19	East Honolulu	WWTP DAF 1	1.0	5%	239	128	107	21	107.5	76	90.47619048	-14.47619048
25-Apr-19	East Honolulu	Lab DAF 1	1.0	5%	273.5294118	130	127.6470588	2.352941176	102.9411765	68.76190476	15.7535014	53.00840336
1-May-19	East Honolulu	WAS	N/A	N/A	N/D	93	114	-21	4900	N/A	N/A	N/A
1-May-19	East Honolulu	WW	N/A	N/A	352	113	105	8	152.5	N/A	N/A	N/A
1-May-19	East Honolulu	Post-Biosorption 0.5	0.5	10%	1029	83	N/D	N/D	655	55.10204082	N/D	N/D
1-May-19	East Honolulu	Post-Biosorption 1	1.0	10%	1120	99	92	7	700	25.71428571	23.87755102	1.836734694
1-May-19	East Honolulu	Lab DAF 1	1.0	10%	158.2352941	94.70588235	93.52941176	1.176470588	52.94117647	33.60144058	21.06842737	12.53301321
1-May-19	East Honolulu	Lab DAF 0.5	0.5	10%	166.4705882	90	N/D	N/D	58.82352941	42.24489796	N/D	N/D
3-May-19	Honouliuli	WW S300 1.5/3.5	N/A	N/A	N/D	139	N/D	N/D	50	N/A	N/A	N/A
3-May-19	Honouliuli	WW S300 1.5/5	N/A	N/A	N/D	130	N/D	N/D	50	N/A	N/A	N/A

Date	WWTP	Sample	DO [mg/l]	AS %	Total COD [mg/l]	sCOD [mg/l]	ffCOD [mg/l]	kCOD [mg/l]	TSS [mg/l]	Normalized sCOD Removal [mg-sCOD/g-TSS]	Normalized ffCOD Removal [mg-ffCOD/g-TSS]	Normalized kCOD Removal [mg-kCOD/g-TSS]
3-May-19	Honouliuli	WW S300 1.5/7	N/A	N/A	N/D	129	N/D	N/D	60	N/A	N/A	N/A
3-May-19	Honouliuli	WW S300 3.0/3.5	N/A	N/A	N/D	122	N/D	N/D	42.5	N/A	N/A	N/A
3-May-19	Honouliuli	WW S300 3.0/7	N/A	N/A	N/D	110	N/D	N/D	47.5	N/A	N/A	N/A
3-May-19	Honouliuli	WW S300 3.0/5	N/A	N/A	N/D	109	N/D	N/D	45	N/A	N/A	N/A
3-May-19	Honouliuli	WW	N/A	N/A	N/D	149	N/D	N/D	180	N/A	N/A	N/A
17-May-19	East Honolulu	WAS	N/A	N/A	N/D	54	19	35	4328.571429	N/A	N/A	N/A
17-May-19	East Honolulu	Lab DAF 0.5	0.5	10%	99.41176471	60.58823529	17.05882353	43.52941176	64.70588235	90.26208503	149.5806639	-59.31857892
17-May-19	East Honolulu	WWTP DAF 0.5	0.5	10%	114	83	58	25	60	43.66336634	64.45544554	-20.79207921
17-May-19	East Honolulu	WW	N/A	N/A	306	104	89	15	137.5	N/A	N/A	N/A
17-May-19	East Honolulu	WWTP DAF 1	1.0	10%	148	40	36	4	75	133.0693069	110.1980198	22.87128713
17-May-19	East Honolulu	Post-Biosorption 1	1.0	10%	764	61	49	12	672.5	89.40594059	83.16831683	6.237623762
17-May-19	East Honolulu	Post-Biosorption 0.5	0.5	10%	906	71	67	4	657.5	68.61386139	45.74257426	22.87128713
17-May-19	East Honolulu	Lab DAF 1	1.0	10%	138.2352941	57.05882353	55.88235294	1.176470588	67.64705882	97.60046593	68.85847408	28.74199185
22-May-19	East Honolulu	WAS	N/A	N/A	N/D	76	82	-6	5320	N/A	N/A	N/A
22-May-19	East Honolulu	WW	N/A	N/A	378	184	142	42	141	N/A	N/A	N/A
5-Jun-19	Honouliuli	WW	N/A	N/A	375	119	106	13	127.5	N/A	N/A	N/A
5-Jun-19	Honouliuli	Post-Biosorption (not centrifuged)	0.5	5%	732	77	74	3	330	173.4782609	132.173913	41.30434783
5-Jun-19	Honouliuli	WAS	N/A	N/A	N/D	75	74	1	4600	N/A	N/A	N/A
7-Jun-19	East Honolulu	WAS	N/A	N/A	N/D	99	110	-11	4920	N/A	N/A	N/A
7-Jun-19	East Honolulu	Lab DAF	0.5	5%	180.5882353	102.9411765	71.17647059	31.76470588	61.76470588	46.56862745	138.3428981	-91.77427068
7-Jun-19	East Honolulu	WW	N/A	N/A	407	115	107	8	122.5	N/A	N/A	N/A
7-Jun-19	East Honolulu	Post-Biosorption (not centrifuged)	0.5	5%	701	77	66	11	352.5	146.7479675	158.3333333	-11.58536585
10-Jun-19	Honouliuli	Lab DAF	0.5	5%	308.2352941	92.94117647	88.23529412	4.705882353	94.11764706	230.8040376	82.99686739	147.8071702
10-Jun-19	Honouliuli	WW	N/A	N/A	404	134	103	31	130	N/A	N/A	N/A
10-Jun-19	Honouliuli	Post-Biosorption (not centrifuged)	0.5	5%	670	106	88	18	320	157.3964497	84.31952663	73.07692308
10-Jun-19	Honouliuli	WAS	N/A	N/A	N/D	103	79	24	3380	N/A	N/A	N/A
10-Jun-19	Honouliuli	WWTP DAF	0.5	5%	296	111	97	14	75	129.2899408	33.72781065	95.56213018
13-Jun-19	East Honolulu	WAS	N/A	N/A	N/D	53	18	35	6420	N/A	N/A	N/A
13-Jun-19	East Honolulu	WWTP DAF	1.0	10%	218	130	121	9	72.5	36.44859813	11.21495327	25.23364486
13-Jun-19	East Honolulu	WW	N/A	N/A	373	156	129	27	167.5	N/A	N/A	N/A
13-Jun-19	East Honolulu	Post-Biosorption (not centrifuged)	1.0	10%	874	140	59	81	557.5	22.42990654	98.13084112	-75.70093458
19-Jun-19	Honouliuli	Lab DAF 10	1.0	10%	231.7647059	98.82352941	89.41176471	9.411764706	67.64705882	202.5937934	55.23390459	147.3598888
19-Jun-19	Honouliuli	WW	N/A	N/A	310	156	105	51	95	N/A	N/A	N/A
19-Jun-19	Honouliuli	Post-Biosorption 5	1.0	5%	523	108	103	5	215	359.0551181	14.96062992	344.0944882
19-Jun-19	Honouliuli	WAS	N/A	N/A	N/D	76	85	-9	2540	N/A	N/A	N/A
19-Jun-19	Honouliuli	WWTP DAF 10	1.0	10%	251	116	70	46	80	141.7322835	124.015748	17.71653543
2-Jul-19	Wahiawa	Lab DAF W	0.5	5%	381.1764706	154.1176471	127.0588235	27.05882353	126.4705882	238.7354942	90.28611445	148.4493798
2-Jul-19	Wahiawa	WWTP DAF W	0.5	5%	342	150	131	19	117.5	252.0408163	77.55102041	174.4897959
2-Jul-19	Wahiawa	Post-Biosorption W	0.5	5%	1127	146	128	18	760	264.9659864	87.24489796	177.7210884
2-Jul-19	Wahiawa	WW W	N/A	N/A	677	228	155	73	225	N/A	N/A	N/A
2-Jul-19	Wahiawa	WAS	N/A	N/A	N/D	33	58	-25	5880	N/A	N/A	N/A
9-Jul-19	Honouliuli	WW	N/A	N/A	353	140	118	22	130	N/A	N/A	N/A
9-Jul-19	Honouliuli	Post-Biosorption 200	1.0	200 ml added	554	101	100	1	277.5	304.6875	140.625	164.0625
9-Jul-19	Honouliuli	Post-Biosorption 400	1.0	400 ml added	704	97	96	1	295	167.96875	85.9375	82.03125
9-Jul-19	Honouliuli	Post-Biosorption 500	1.0	500 ml added	858	97	87	10	480	134.375	96.875	37.5
9-Jul-19	Honouliuli	Post-Biosorption 300	1.0	300 ml added	654	126	90	36	285	72.91666667	145.8333333	-72.91666667
9-Jul-19	Honouliuli	WAS	N/A	N/A	N/D	80	82	-2	3200	N/A	N/A	N/A
19-Jul-19	Wahiawa	WWTP DAF W 10	1.0	10%	536	186	142	44	200	93.15789474	60	33.15789474
19-Jul-19	Wahiawa	Post-Biosorption W 10	1.0	10%	1142	169	153	16	547.5	120	42.63157895	77.36842105
19-Jul-19	Wahiawa	Lab DAF W 10	1.0	10%	637.6470588	162.3529412	148.2352941	14.11764706	276.4705882	130.495356	50.15479876	80.34055728
19-Jul-19	Wahiawa	Lab DAF W 5	1.0	5%	510.5882353	196.4705882	145.8823529	50.58823529	179.4117647	161.7647059	113.7254902	48.03921569
19-Jul-19	Wahiawa	Post-Biosorption W 5	1.0	5%	946	181	169	12	395	213.3333333	36.66666667	176.6666667
19-Jul-19	Wahiawa	WWTP DAF W 5	1.0	5%	472	178	145	33	162.5	223.3333333	116.6666667	106.6666667
19-Jul-19	Wahiawa	WW W	N/A	N/A	646	245	180	65	215	N/A	N/A	N/A
19-Jul-19	Wahiawa	WAS	N/A	N/A	N/D	114	186	-72	5700	N/A	N/A	N/A
22-Jul-19	Honouliuli	Post-Biosorption 5 S180	1.0	5%	518	115	101	14	202.5	236.1271676	137.283237	98.84393064
22-Jul-19	Honouliuli	Post-Biosorption 10 S300	1.0	10%	679	92	84	8	357.5	171.6763006	109.2485549	62.42774566
22-Jul-19	Honouliuli	Post-Biosorption 5 S300	1.0	5%	537	110	91	19	225	263.583815	192.1965318	71.38728324
22-Jul-19	Honouliuli	Lab DAF 10	1.0	10%	238.8235294	87.05882353	87.05882353	0	100	184.5290717	101.2920775	83.23699422
22-Jul-19	Honouliuli	Lab DAF 5	1.0	5%	257.6470588	103.5294118	96.47058824	7.058823529	82.35294118	299.115947	162.1557293	136.9602176
22-Jul-19	Honouliuli	Post-Biosorption 10 Sett 5	1.0	10%	366	102	77	25	155	145.6647399	127.4566474	18.20809249
22-Jul-19	Honouliuli	Post-Biosorption 5 Sett 10	1.0	5%	349	121	102	19	115	203.1791908	131.7919075	71.38728324
22-Jul-19	Honouliuli	Post-Biosorption 5 Sett 5	1.0	5%	501	110	107	3	200	263.583815	104.3352601	159.2485549

Date	WWTP	Sample	DO [mg/l]	AS %	Total COD [mg/l]	sCOD [mg/l]	ffCOD [mg/l]	kCOD [mg/l]	TSS [mg/l]	Normalized sCOD Removal [mg-sCOD/g-TSS]	Normalized ffCOD Removal [mg-ffCOD/g-TSS]	Normalized kCOD Removal [mg-kCOD/g-TSS]
22-Jul-19	Honouliuli	WW	N/A	N/A	440	158	126	32	142.5	N/A	N/A	N/A
22-Jul-19	Honouliuli	Post-Biosorption 10	1.0	10%	870	102	75	27	477.5	145.6647399	132.6589595	13.00578035
22-Jul-19	Honouliuli	WAS	N/A	N/A	N/D	81	83	-2	3460	N/A	N/A	N/A
22-Jul-19	Honouliuli	WWTP DAF 10	1.0	10%	262	86	70	16	105	187.283237	145.6647399	41.61849711
22-Jul-19	Honouliuli	WWTP DAF 5	1.0	5%	267	113	99	14	87.5	247.1098266	148.265896	98.84393064
24-Jul-19	Wahiawa	WW W	N/A	N/A	698	232	182	50	225	N/A	N/A	N/A
24-Jul-19	Wahiawa	Lab DAF W	0.5	10%	404.7058824	136.4705882	101.1764706	35.29411765	173.5294118	78.16042781	66.12834225	12.03208556
24-Jul-19	Wahiawa	Post-Biosorption W	0.5	10%	1646	141	108	33	1020	74.45454545	60.54545455	13.90909091
24-Jul-19	Wahiawa	WAS	N/A	N/A	N/D	43	54	-11	11000	N/A	N/A	N/A
26-Jul-19	Waimanalo	WWTP DAF	1.0	10%	310	141	98	43	97.5	208.2857143	231.4285714	-23.14285714
26-Jul-19	Waimanalo	Lab DAF	1.0	10%	308.2352941	131.7647059	108.2352941	23.52941176	97.05882353	243.907563	191.9495798	51.95798319
26-Jul-19	Waimanalo	WW	N/A	N/A	592	195	158	37	222.5	N/A	N/A	N/A
26-Jul-19	Waimanalo	Post-Biosorption (not centrifuged)	1.0	10%	1109	111	97	14	475	324	235.2857143	88.71428571
26-Jul-19	Waimanalo	WAS	N/A	N/A	N/D	30	64	-34	2333.333333	N/A	N/A	N/A
29-Jul-19	Honouliuli	Post-Biosorption (not centrifuged)	1.0	5%	676	105	99	6	302.5	129.4637224	67.12933754	62.33438486
29-Jul-19	Honouliuli	WAS	N/A	N/A	N/D	67	67	0	3962.5	N/A	N/A	N/A
29-Jul-19	Honouliuli	WW	N/A	N/A	426	132	113	19	115	N/A	N/A	N/A
1-Aug-19	Waimanalo	WW	N/A	N/A	519	229	160	69	125	N/A	N/A	N/A
1-Aug-19	Waimanalo	Post-Biosorption (not centrifuged)	1.0	5%	675	207	138	69	282.5	163.4636872	163.4636872	0
1-Aug-19	Waimanalo	WAS	N/A	N/A	N/D	48	69	-21	2557.142857	N/A	N/A	N/A
2-Aug-19	Honouliuli	WAS	N/A	N/A	N/D	80	68	12	3111.111111	N/A	N/A	N/A
2-Aug-19	Honouliuli	WW	N/A	N/A	404	151	120	31	120	N/A	N/A	N/A
2-Aug-19	Honouliuli	Post-Biosorption 100	1.0	100ml added	463	121	104	17	190	482.1428571	257.1428571	225
2-Aug-19	Honouliuli	Post-Biosorption 200	1.0	200ml added	642	102	90	12	237.5	393.75	241.0714286	152.6785714
2-Aug-19	Honouliuli	Post-Biosorption 300	1.0	300ml added	678	113	86	27	330	203.5714286	182.1428571	21.42857143
2-Aug-19	Honouliuli	Post-Biosorption 400	1.0	400ml added	825	104	91	13	357.5	188.8392857	116.5178571	72.32142857
2-Aug-19	Honouliuli	Post-Biosorption 500	1.0	500ml added	902	97	81	16	462.5	173.5714286	125.3571429	48.21428571
5-Aug-19	Honouliuli	WAS	N/A	N/A	N/D	108	113	-5	3840	N/A	N/A	N/A
5-Aug-19	Honouliuli	WW	N/A	N/A	452	161	139	22	140	N/A	N/A	N/A
5-Aug-19	Honouliuli	Post-Biosorption 60min	1.0	5%	728	87	80	7	315	366.1458333	291.9270833	74.21875
5-Aug-19	Honouliuli	Post-Biosorption 30min	1.0	5%	N/D	97	94	3	312.5	316.6666667	222.65625	94.01041667
5-Aug-19	Honouliuli	Post-Biosorption 40min	1.0	5%	764	106	90	16	310	272.1354167	242.4479167	29.6875
5-Aug-19	Honouliuli	Post-Biosorption 20min	1.0	5%	805	121	111	10	325	197.9166667	138.5416667	59.375
5-Aug-19	Honouliuli	Post-Biosorption 10min	1.0	5%	700	123	121	2	320	188.0208333	89.0625	98.95833333
7-Aug-19	Wahiawa	WW	N/A	N/A	660	227	163	64	187.5	N/A	N/A	N/A
7-Aug-19	Wahiawa	WAS	N/A	N/A	N/D	41	48	-7	6444.444444	N/A	N/A	N/A
8-Aug-19	Waimanalo	WW	N/A	N/A	619	257	182	75	160	N/A	N/A	N/A
8-Aug-19	Waimanalo	Post-Biosorption (not centrifuged)	0.5	5%	811	240	157	83	317.5	88.49315068	130.1369863	-41.64383562
8-Aug-19	Waimanalo	WAS	N/A	N/A	N/D	43	61	-18	3650	N/A	N/A	N/A
12-Aug-19	Honouliuli	WAS	N/A	N/A	N/D	75	73	2	3733.333333	N/A	N/A	N/A
12-Aug-19	Honouliuli	WW	N/A	N/A	377	143	109	34	117.5	N/A	N/A	N/A
12-Aug-19	Honouliuli	Post-Biosorption 50min	1.0	5%	602	94	91	3	262.5	249.375	91.60714286	157.7678571
12-Aug-19	Honouliuli	Post-Biosorption 60min	1.0	5%	710	95	90	5	270	244.2857143	96.69642857	147.5892857
12-Aug-19	Honouliuli	Post-Biosorption 200	1.0	200ml added	712	110	85	25	245	220.9821429	160.7142857	60.26785714
12-Aug-19	Honouliuli	Post-Biosorption 40min	1.0	5%	606	101	93	8	277.5	213.75	81.42857143	132.3214286
12-Aug-19	Honouliuli	Post-Biosorption 30min	1.0	5%	666	108	94	14	420	178.125	76.33928571	101.7857143
12-Aug-19	Honouliuli	Post-Biosorption 300	1.0	300ml added	672	105	88	17	300	169.6428571	93.75	75.89285714
12-Aug-19	Honouliuli	Post-Biosorption 20min	1.0	5%	677	111	112	-1	262.5	162.8571429	-15.26785714	178.125
12-Aug-19	Honouliuli	Post-Biosorption 400	1.0	400ml added	829	95	86	9	355	160.7142857	77.00892857	83.70535714
12-Aug-19	Honouliuli	Post-Biosorption 500	1.0	500ml added	735	93	93	0	380	133.9285714	42.85714286	91.07142857
12-Aug-19	Honouliuli	Post-Biosorption 10min	1.0	5%	629	117	115	2	252.5	132.3214286	-30.53571429	162.8571429
12-Aug-19	Honouliuli	Post-Biosorption 100	1.0	100ml added	486	136	109	27	185	93.75	0	93.75
14-Aug-19	Wahiawa	WW	N/A	N/A	685	297	197	100	172.5	N/A	N/A	N/A
14-Aug-19	Wahiawa	Post-Biosorption (centrifuged)	0.5	10%	1585	164	116	48	1007.142857	194.8604651	118.6744186	76.18604651
14-Aug-19	Wahiawa	WAS	N/A	N/A	N/D	36	58	-22	6142.857143	N/A	N/A	N/A
15-Aug-19	Waimanalo	WW	N/A	N/A	581	240	169	71	157.5	N/A	N/A	N/A
15-Aug-19	Waimanalo	Post-Biosorption (not centrifuged)	0.5	10%	742	156	121	35	397.5	312.3966942	178.5123967	133.8842975
15-Aug-19	Waimanalo	WAS	N/A	N/A	N/D	22	47	-25	2420	N/A	N/A	N/A
19-Aug-19	Honouliuli	WAS	N/A	N/A	N/D	103	111	-8	3133.333333	N/A	N/A	N/A
19-Aug-19	Honouliuli	WW	N/A	N/A	410	165	140	25	125	N/A	N/A	N/A
19-Aug-19	Honouliuli	Post-Biosorption 10min	1.0	5%	652	124	110	14	262.5	248.6170213	181.9148936	66.70212766
19-Aug-19	Honouliuli	Post-Biosorption 20min	1.0	5%	660	124	118	6	237.5	248.6170213	133.4042553	115.212766
19-Aug-19	Honouliuli	Post-Biosorption 30min	1.0	5%	659	126	105	21	247.5	236.4893617	212.2340426	24.25531915

Date	WWTP	Sample	DO [mg/l]	AS %	Total COD [mg/l]	sCOD [mg/l]	ffCOD [mg/l]	kCOD [mg/l]	TSS [mg/l]	Normalized sCOD Removal [mg-sCOD/g-TSS]	Normalized ffCOD Removal [mg-ffCOD/g-TSS]	Normalized kCOD Removal [mg-kCOD/g-TSS]
19-Aug-19	Honouliuli	Post-Biosorption 40min	1.0	5%	646	110	92	18	260	333.5106383	291.0638298	42.44680851
19-Aug-19	Honouliuli	Post-Biosorption 50min	1.0	5%	630	118	108	10	257.5	285	194.0425532	90.95744681
19-Aug-19	Honouliuli	Post-Biosorption 70min	1.0	5%	593	101	96	5	275	388.0851064	266.8085106	121.2765957
19-Aug-19	Honouliuli	Post-Biosorption 80min	1.0	5%	638	96	90	6	267.5	418.4042553	303.1914894	115.212766
19-Aug-19	Honouliuli	Post-Biosorption 90min	1.0	5%	671	101	84	17	287.5	388.0851064	339.5744681	48.5106383
20-Aug-19	East Honolulu	WAS	N/A	N/A	N/D	89	130	-41	5536.363636	N/A	N/A	N/A
20-Aug-19	East Honolulu	WW	N/A	N/A	353	166	166	0	132.5	N/A	N/A	N/A
20-Aug-19	East Honolulu	Post-Biosorption (not centrifuged)	0.5	5%	686	135	107	28	365	106.3875205	202.4794745	-96.09195402
21-Aug-19	Wahiawa	Post-Biosorption (centrifuged)	0.5	10%	1720	154	121	33	1032.258065	178.7234043	90.63829787	88.08510638
21-Aug-19	Wahiawa	WW	N/A	N/A	712	294	192	102	257.5	N/A	N/A	N/A
21-Aug-19	Wahiawa	WAS	N/A	N/A	N/D	52	55	-3	7050	N/A	N/A	N/A
23-Aug-19	Waimanalo	WW	N/A	N/A	533	246	152	94	117.5	N/A	N/A	N/A
23-Aug-19	Waimanalo	Post-Biosorption (not centrifuged)	0.5	5%	630	214	149	65	252.5	266.1279461	24.94949495	241.1784512
23-Aug-19	Waimanalo	WAS	N/A	N/A	3524	30	44	-14	2284.615385	N/A	N/A	N/A
29-Aug-19	Waimanalo	WW	N/A	N/A	557	273	186	87	140	N/A	N/A	N/A
29-Aug-19	Waimanalo	Post-Biosorption (not centrifuged)	0.5	5%	628	225	154	71	242.5	506.6666667	337.7777778	168.8888889
29-Aug-19	Waimanalo	WAS	N/A	N/A	2684	46	54	-8	1800	N/A	N/A	N/A
5-Sep-19	Waimanalo	WW	N/A	N/A	589	248	148	100	170	N/A	N/A	N/A
5-Sep-19	Waimanalo	Post-Biosorption (not centrifuged)	1.0	5%	696	189	130	59	287.5	501.9402985	153.1343284	348.8059701
5-Sep-19	Waimanalo	WAS	N/A	N/A	3396	43	50	-7	2233.333333	N/A	N/A	N/A
9-Sep-19	Honouliuli	WAS	N/A	N/A	4080	89	75	14	2450	N/A	N/A	N/A
9-Sep-19	Honouliuli	WW	N/A	N/A	366	158	107	51	110	N/A	N/A	N/A
9-Sep-19	Honouliuli	Post-Biosorption 5	0.5	5%	612	102	96	6	235	434.2857143	85.30612245	348.9795918
9-Sep-19	Honouliuli	Post-Biosorption 10	0.5	10%	778	128	96	32	380	110.2040816	40.40816327	69.79591837
11-Sep-19	Waimanalo	WW	N/A	N/A	482	223	164	59	127.5	N/A	N/A	N/A
11-Sep-19	Waimanalo	Post-Biosorption (not centrifuged)	0.5	10%	805	159	102	57	337.5	250.4347826	242.6086957	7.826086957
11-Sep-19	Waimanalo	WAS	N/A	N/A	3388	38	52	-14	2300	N/A	N/A	N/A
13-Sep-19	Wahiawa	Post-Biosorption (centrifuged)	1.0	5%	1114	245	166	79	422.5	206.2040134	31.4548495	174.7491639
13-Sep-19	Wahiawa	WAS	N/A	N/A	7780	43	50	-7	5436.363636	N/A	N/A	N/A
13-Sep-19	Wahiawa	WW	N/A	N/A	744	304	175	129	182.5	N/A	N/A	N/A
18-Sep-19	Waimanalo	WWTP DAF	1.0	10%	255	96	91	5	60	471.0591133	218.5714286	252.4876847
18-Sep-19	Waimanalo	WW	N/A	N/A	502	221	149	72	152.5	N/A	N/A	N/A
18-Sep-19	Waimanalo	Lab DAF	1.0	10%	277.6470588	110.5882353	107.0588235	3.529411765	64.70588235	416.0837438	158.0541872	258.0295567
18-Sep-19	Waimanalo	Post-Biosorption (not centrifuged)	1.0	10%	829	121	84	37	392.5	376.8472906	244.9507389	131.8965517
18-Sep-19	Waimanalo	WAS	N/A	N/A	3472	44	60	-16	2388.235294	N/A	N/A	N/A
23-Sep-19	Honouliuli	Post-Biosorption (not centrifuged)	0.5	10%	857	74	66	8	385	335.5029586	162.9585799	172.5443787
23-Sep-19	Honouliuli	WAS	N/A	N/A	5080	59	64	-5	2816.666667	N/A	N/A	N/A
23-Sep-19	Honouliuli	WW	N/A	N/A	484	179	117	62	110	N/A	N/A	N/A
26-Sep-19	Waimanalo	Post-Biosorption (not centrifuged)	1.0	5%	715	161	120	41	302.5	641.25	313.6548913	327.5951087
26-Sep-19	Waimanalo	WWTP DAF	1.0	5%	290	216	150	66	65	257.8940217	104.5516304	153.3423913
26-Sep-19	Waimanalo	Lab DAF	1.0	5%	336.4705882	145.8823529	135.2941176	10.58823529	61.76470588	746.6216432	207.0532289	539.5684143
26-Sep-19	Waimanalo	WW	N/A	N/A	564	253	165	88	162.5	N/A	N/A	N/A
26-Sep-19	Waimanalo	WAS	N/A	N/A	4550	58	70	-12	2725.925926	N/A	N/A	N/A
3-Oct-19	Wahiawa	Post-Biosorption (not centrifuged)	0.5	5%	1109	191	139	52	467.5	411.738149	133.8148984	277.9232506
3-Oct-19	Wahiawa	WAS	N/A	N/A	8400	74	47	27	5537.5	N/A	N/A	N/A
3-Oct-19	Wahiawa	WW	N/A	N/A	688	311	178	133	185	N/A	N/A	N/A
3-Oct-19	Wahiawa	Lab DAF	0.5	5%	470.5882353	216.4705882	154.1176471	62.35294118	126.4705882	324.3447085	81.94396494	242.4007436
3-Oct-19	Wahiawa	WWTP DAF	0.5	5%	428	188	153	35	110	422.0316027	85.77878104	336.2528217
17-Oct-19	Wahiawa	Post-Biosorption (centrifuged)	1.0	10%	1496	243	115	128	900	31.44104803	78.60262009	-47.16157205
17-Oct-19	Wahiawa	WAS	N/A	N/A	8330	83	57	26	5725	N/A	N/A	N/A
17-Oct-19	Wahiawa	WW	N/A	N/A	675	263	165	98	207.5	N/A	N/A	N/A
17-Oct-19	Wahiawa	Lab DAF	1.0	10%	323.5294118	140	101.1764706	38.82352941	108.8235294	193.3624454	100.3339327	93.02851272
17-Oct-19	Wahiawa	WWTP DAF	1.0	10%	322	122	109	13	107.5	221.6593886	88.0349345	133.6244541
23-Oct-19	Honouliuli	Lab DAF	1.0	10%	269.4117647	172.9411765	165.8823529	7.058823529	52.94117647	205.3915966	88.32605042	117.0655462
23-Oct-19	Honouliuli	WWTP DAF	1.0	10%	267	171	161	10	60	211.7142857	104.2285714	107.4857143
23-Oct-19	Honouliuli	WAS	N/A	N/A	5250	58	61	-3	2763.157895	N/A	N/A	N/A
23-Oct-19	Honouliuli	WW	N/A	N/A	477	236	193	43	127.5	N/A	N/A	N/A
24-Oct-19	Honouliuli	WAS	N/A	N/A	4140	64	55	9	2506.666667	N/A	N/A	N/A
24-Oct-19	Honouliuli	WW	N/A	N/A	383	137	124	13	135	N/A	N/A	N/A
24-Oct-19	Honouliuli	Post-Biosorption (not centrifuged)	1.0	10%	698	88	81	7	315	175.9308511	154.3882979	21.54255319
25-Oct-19	Honouliuli	WAS	N/A	N/A	3788	58	70	-12	2291.666667	N/A	N/A	N/A
25-Oct-19	Honouliuli	WW	N/A	N/A	391	112	92	20	125	N/A	N/A	N/A
25-Oct-19	Honouliuli	Post-Biosorption (not centrifuged)	1.0	10%	698	86	71	15	330	102.1090909	82.47272727	19.63636364

Date	WWTP	Sample	DO [mg/l]	AS %	Total COD [mg/l]	sCOD [mg/l]	ffCOD [mg/l]	kCOD [mg/l]	TSS [mg/l]	Normalized sCOD Removal [mg-sCOD/g-TSS]	Normalized ffCOD Removal [mg-ffCOD/g-TSS]	Normalized kCOD Removal [mg-kCOD/g-TSS]
31-Oct-19	Honouliuli	Lab DAF	1.0	10%	268.2352941	104.7058824	97.64705882	7.058823529	70.58823529	179.8442907	56.98961938	122.8546713
31-Oct-19	Honouliuli	WWTP DAF	1.0	10%	222	94	83	11	60	222.3529412	115.1470588	107.2058824
31-Oct-19	Honouliuli	WAS	N/A	N/A	3584	75	71	4	2266.666667	N/A	N/A	N/A
31-Oct-19	Honouliuli	WW	N/A	N/A	399	150	112	38	113	N/A	N/A	N/A
31-Oct-19	Honouliuli	Post-Biosorption (not centrifuged)	1.0	10%	856	101	84	17	330	194.5588235	111.1764706	83.38235294

Author	Year	Extraction Method	EPS Source	Sludge Type	Proteins		Carbohydrates/Polysaccharides			P/C	Humic Acids		Lipids		Nucleic Acids/DNA			Uronic Acids			U/C	Unknown		Sum	Unit
					[mg/g]	% of Sum	Method	[mg/g]	% of Sum		[mg/g]	% of Sum	[mg/g]	% of Sum	Method	[mg/g]	% of Sum	Method	[mg/g]	% of Sum		[mg/g]	% of Sum		
Park	2007	Base	WWTP	Aerobic	42.90	N/D	Dubois, 1956	17.90	N/D	2.40	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	mg/g-VS-Sludge
Park	2007	Base	WWTP	Aerobic	42.40	N/D	Dubois, 1956	16.60	N/D	2.55	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	mg/g-VS-Sludge
Park	2007	Base	WWTP	Aerobic	40.70	N/D	Dubois, 1956	15.90	N/D	2.56	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	mg/g-VS-Sludge
Park	2007	Base	WWTP	Aerobic	31.10	N/D	Dubois, 1956	11.40	N/D	2.73	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	mg/g-VS-Sludge
Park	2007	Base	WWTP	Aerobic	49.70	N/D	Dubois, 1956	15.30	N/D	3.25	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	mg/g-VS-Sludge
Park	2007	Base	WWTP	Aerobic	47.40	N/D	Dubois, 1956	11.40	N/D	4.16	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	mg/g-VS-Sludge
Park	2007	Base	WWTP	Aerobic	40.40	N/D	Dubois, 1956	9.60	N/D	4.21	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	mg/g-VS-Sludge
Liang	2010	Base	Lab-Scale Reactor	Aerobic	64.00	58.66%	Gaudy, 1962	18.00	16.50%	3.56	25.00	22.91%	N/D	N/D	Picogreen	2.10	1.92%	N/D	N/D	N/D	N/D	N/D	N/D	109.10	mg/g-VSS-Biofilm
Park	2008	Base	WWTP	Aerobic	68.70	N/D	Dubois, 1956	22.40	N/D	3.07	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	mg/g-VS-Sludge
Park	2008	Base	WWTP	Aerobic	42.40	N/D	Dubois, 1956	12.80	N/D	3.31	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	mg/g-VS-Sludge
Park	2008	Base	WWTP	Aerobic	41.30	N/D	Dubois, 1956	12.10	N/D	3.41	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	mg/g-VS-Sludge
Park	2008	Base	WWTP	Aerobic	47.40	N/D	Dubois, 1956	11.40	N/D	4.16	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	mg/g-VS-Sludge
Park	2008	Base	WWTP	Aerobic	31.00	N/D	Dubois, 1956	8.40	N/D	3.69	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	mg/g-VS-Sludge
Comte (a)	2006	Centrifuge	WWTP	Aerobic	317.00	51.05%	Dubois, 1956	170.00	27.38%	1.86	63.00	10.14%	32.00	5.15%	Burton, 1956	39.00	6.28%	Blumenkrantz, 1973	21.00	3.38%	0.12	N/D	N/D	621.00	mg/g-VS-Sludge
Comte (a)	2006	Centrifuge	WWTP	Aerobic	249.00	42.06%	Dubois, 1956	157.00	26.52%	1.59	149.00	25.17%	25.00	4.22%	Burton, 1956	12.00	2.03%	Blumenkrantz, 1973	59.00	9.97%	0.38	N/D	N/D	592.00	mg/g-VS-Sludge
Comte (b)	2006	Centrifuge	WWTP	Aerobic	385.00	52.74%	Dubois, 1956	207.00	28.36%	1.86	77.00	10.55%	39.00	5.34%	Burton, 1956	22.00	3.01%	Blumenkrantz, 1973	25.00	3.42%	0.12	N/D	N/D	730.00	mg/g-VDW-EPS
Comte (b)	2006	Centrifuge	WWTP	Aerobic	334.00	39.43%	Dubois, 1956	210.00	24.79%	1.59	201.00	23.73%	33.00	3.90%	Burton, 1956	69.00	8.15%	Blumenkrantz, 1973	80.00	9.45%	0.38	N/D	N/D	847.00	mg/g-VDW-EPS
Liu	2002	Centrifuge	Municipal WWTP	Aerobic	7.90	31.40%	Gaudy, 1962	7.70	30.60%	1.03	6.40	25.44%	N/D	N/D	Sun, 1999	0.06	0.24%	Kintner, 1982	0.50	1.99%	0.06	3.10	12.32%	25.16	mg/g-VS-Sludge
Liang	2010	Centrifuge	Lab-Scale Reactor	Aerobic	6.00	45.11%	Gaudy, 1962	3.00	22.56%	2.00	4.00	30.08%	N/D	N/D	Picogreen	0.30	2.26%	N/D	N/D	N/D	N/D	N/D	N/D	13.30	mg/g-VSS-Biofilm
Comte (a)	2006	CER	WWTP	Aerobic	301.00	51.45%	Dubois, 1956	132.00	22.56%	2.28	107.00	18.29%	21.00	3.59%	Burton, 1956	24.00	4.10%	Blumenkrantz, 1973	47.00	8.03%	0.36	N/D	N/D	585.00	mg/g-VS-Sludge
Comte (a)	2006	CER	WWTP	Aerobic	322.00	52.44%	Dubois, 1956	126.00	20.52%	2.56	129.00	21.01%	21.00	3.42%	Burton, 1956	16.00	2.61%	Blumenkrantz, 1973	54.00	8.79%	0.43	N/D	N/D	614.00	mg/g-VS-Sludge
Comte (b)	2006	CER	WWTP	Aerobic	381.00	45.36%	Dubois, 1956	162.00	19.29%	2.35	224.00	26.67%	22.00	2.62%	Burton, 1956	51.00	6.07%	Blumenkrantz, 1973	71.00	8.45%	0.44	N/D	N/D	840.00	mg/g-VDW-EPS
Comte (b)	2006	CER	WWTP	Aerobic	365.00	46.26%	Dubois, 1956	149.00	18.88%	2.45	182.00	23.07%	20.00	2.53%	Burton, 1956	73.00	9.25%	Blumenkrantz, 1973	69.00	8.75%	0.46	N/D	N/D	789.00	mg/g-VDW-EPS
Park	2007	CER	WWTP	Aerobic	41.00	N/D	Dubois, 1956	21.30	N/D	1.92	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	mg/g-VS-Sludge
Park	2007	CER	WWTP	Aerobic	41.00	N/D	Dubois, 1956	21.30	N/D	1.92	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	mg/g-VS-Sludge
Park	2007	CER	WWTP	Aerobic	58.70	N/D	Dubois, 1956	29.20	N/D	2.01	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	mg/g-VS-Sludge
Park	2007	CER	WWTP	Aerobic	49.10	N/D	Dubois, 1956	23.20	N/D	2.12	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	mg/g-VS-Sludge
Park	2007	CER	WWTP	Aerobic	51.30	N/D	Dubois, 1956	20.80	N/D	2.47	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	mg/g-VS-Sludge
Park	2007	CER	WWTP	Aerobic	64.50	N/D	Dubois, 1956	25.40	N/D	2.54	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	mg/g-VS-Sludge
Park	2007	CER	WWTP	Aerobic	73.40	N/D	Dubois, 1956	26.10	N/D	2.81	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	mg/g-VS-Sludge
Park	2007	CER	WWTP	Aerobic	36.70	N/D	Dubois, 1956	13.00	N/D	2.82	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	mg/g-VS-Sludge
Frolund	1996	CER	Traditional WWTP	Aerobic	243.00	58.27%	Gaudy, 1962	48.00	11.51%	5.06	126.00	30.22%	N/D	N/D	N/D	N/D	N/D	Kintner, 1982	6.10	1.46%	0.13	N/D	N/D	417.00	mg/g-VS-Sludge
Liu	2002	CER	Municipal WWTP	Aerobic	17.60	31.07%	Gaudy, 1962	12.70	22.42%	1.39	16.40	28.95%	N/D	N/D	Sun, 1999	0.14	0.25%	Kintner, 1982	1.20	2.12%	0.09	9.80	17.30%	56.64	mg/g-VS-Sludge
Wilen	2003	CER	WWTP	Aerobic	78.00	45.61%	Gaudy, 1962	15.00	8.77%	5.20	67.00	39.18%	N/D	N/D	Brunk, 1979	11.00	6.43%	Kintner, 1982	3.00	1.75%	0.20	N/D	N/D	171.00	mg/g-VSS-EPS
Liang	2010	CER	Lab-Scale Reactor	Aerobic	49.00	58.13%	Gaudy, 1962	14.00	16.61%	3.50	20.00	23.72%	N/D	N/D	Picogreen	1.30	1.54%	N/D	N/D	N/D	N/D	N/D	N/D	84.30	mg/g-VSS-Biofilm
Park	2008	CER	WWTP	Aerobic	74.00	N/D	Dubois, 1956	33.40	N/D	2.22	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	mg/g-VS-Sludge
Park	2008	CER	WWTP	Aerobic	70.00	N/D	Dubois, 1956	36.80	N/D	1.90	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	mg/g-VS-Sludge
Park	2008	CER	WWTP	Aerobic	59.70	N/D	Dubois, 1956	22.80	N/D	2.62	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	mg/g-VS-Sludge
Park	2008	CER	WWTP	Aerobic	73.40	N/D	Dubois, 1956	26.10	N/D	2.81	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	mg/g-VS-Sludge
Park	2008	CER	WWTP	Aerobic	70.00	N/D	Dubois, 1956	21.90	N/D	3.20	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	mg/g-VS-Sludge
Liu	2002	Formaldehyde	Municipal WWTP	Aerobic	12.30	25.32%	Gaudy, 1962	15.90	32.74%	0.77	10.90	22.44%	N/D	N/D	Sun, 1999	0.07	0.14%	Kintner, 1982	1.10	2.26%	0.07	9.40	19.35%	48.57	mg/g-VS-Sludge
Liu	2002	Formaldehyde + NaOH	Municipal WWTP	Aerobic	54.60	33.99%	Gaudy, 1962	40.50	25.21%	1.35	50.40	31.37%	N/D	N/D	Sun, 1999	0.35	0.22%	Kintner, 1982	4.20	2.61%	0.10	14.80	9.21%	160.65	mg/g-VS-Sludge
Liu	2002	Formaldehyde + Sonication	Municipal WWTP	Aerobic	20.40	26.80%	Gaudy, 1962	28.90	37.96%	0.71	18.90	24.83%	N/D	N/D	Sun, 1999	0.13	0.17%	Kintner, 1982	1.80	2.36%	0.06	7.80	10.25%	76.13	mg/g-VS-Sludge
Comte (a)	2006	Heat	WWTP	Aerobic	296.00	53.24%	Dubois, 1956	183.00	32.91%	1.62	57.00	10.25%	10.00	1.80%	Burton, 1956	10.00	1.80%	Blumenkrantz, 1973	30.00	5.40%	0.16	N/D	N/D	556.00	mg/g-VS-Sludge
Comte (a)	2006	Heat	WWTP	Aerobic	378.00	54.31%	Dubois, 1956	166.00	23.85%	2.28	126.00	18.10%	9.00	1.29%	Burton, 1956	17.00	2.44%	Blumenkrantz, 1973	37.00	5.32%	0.22	N/D	N/D	696.00	mg/g-VS-Sludge
Liang	2010	LB-EPS	Lab-Scale Reactor	Aerobic	9.20	50.27%	Gaudy, 1962	4.00	21.86%	2.30	4.30	23.50%	N/D	N/D	Picogreen	0.80	4.37%	N/D	N/D	N/D	N/D	N/D	N/D	18.30	mg/g-VSS-Biofilm
Liang	2010	Pellets	Lab-Scale Reactor	Aerobic	78.00	56.12%	Gaudy, 1962	29.00	20.86%	2.69	26.00	18.71%	N/D	N/D	Picogreen	6.00	4.32%	N/D	N/D	N/D	N/D	N/D	N/D	139.00	mg/g-VSS-Biofilm
Liang	2010	SMP	Lab-Scale Reactor	Aerobic	5.00	45.87%	Gaudy, 1962	2.50	22.94%	2.00	3.00	27.52%	N/D	N/D	Picogreen	0.40	3.67%	N/D	N/D	N/D	N/D	N/D	N/D	10.90	mg/g-VSS-Biofilm
Guibaud	2005	Sonication	Domestic WWTP	Aerobic	343.00	58.14%	Dubois, 1956	140.00	23.73%	2.45	61.00	10.34%	N/D	N/D	Burton, 1956	46.00	7.80%	Blumenkrantz, 1973	15.00	2.54%	0.11	N/D	N/D	590.00	mg/g-DW-EPS
Comte (a)	2006	Sonication	WWTP	Aerobic	343.00	56.23%	Dubois, 1956	140.00	22.95%	2.45	61.00	10.00%	20.00	3.28%	Burton, 1956	46.00	7.54%	Blumenkrantz, 1973	16.00	2.62%	0.11	N/D	N/D	610.00	mg/g-VS-Sludge
Comte (a)	2006	Sonication	WWTP	Aerobic	337.00	49.63%	Dubois, 1956	136.00	20.03%	2.48	177.00	26.07%	18.00	2.65%	Burton, 1956	11.00	1.62%	Blumenkrantz, 1973	55.00	8.10%	0.40	N/D	N/D	679.00	mg/g-VS-Sludge
Liang	2010	Sonication	Lab-Scale Reactor	Aerobic	79.00	65.07%	Gaudy, 1962	18.00	14.83%	4.39	23.00	18.95%	N/D	N/D	Picogreen	1.40	1.15%	N/D	N/D	N/D	N/D	N/D	N/D	121.40	mg/g-VSS-Biofilm
Comte (a)	2006	Sonication + CER	WWTP	Aerobic	266.00	45.39%	Dubois, 1956	113.00	19.28%	2.35	156.00	26.62%	16.00	2.73%	Burton, 1956	35.00	5.97%	Blumenkrantz, 1973	50.00	8.53%	0.44	N/D	N/D	586.00	mg/g-VS-Sludge
Comte (a)	2006	Sonication + CER	WWTP	Aerobic	252.00	48.46%	Dubois, 1956	103.00	19.81%	2.45	126.00	24.23%	14.00	2.69%	Burton, 1956	25.00	4.81%	Blumenkrantz, 1973	47.00	9.04%	0.46	N/D	N/D	520.00	mg/g-VS-Sludge
Park	2007	Sulfide	WWTP	Aerobic	37.10	N/D	Dubois, 1956	12.80	N/D	2.90	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	mg/g-VS-Sludge
Park	2007	Sulfide	WWTP	Aerobic	16.00	N/D	Dubois, 1956	4.60	N/D	3.48	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	mg/g-VS-Sludge
Park	2007	Sulfide	WWTP	Aerobic	34.00	N/D	Dubois, 1956	9.70	N/D	3.51	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	mg/g-VS-Sludge
Park	2007	Sulfide	WWTP	Aerobic	18.90	N/D	Dubois, 1956	5.00	N/D	3.78	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	mg/g-VS-Sludge

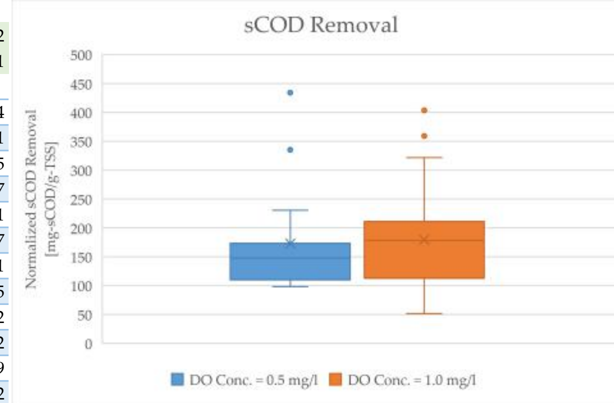
Author	Year	Extraction Method	EPS Source	Sludge Type	Proteins		Carbohydrates/Polysaccharides			P/C	Humic Acids		Lipids		Nucleic Acids/DNA			Uronic Acids			U/C	Unknown		Sum	Unit
					[mg/g]	% of Sum	Method	[mg/g]	% of Sum		[mg/g]	% of Sum	[mg/g]	% of Sum	Method	[mg/g]	% of Sum	Method	[mg/g]	% of Sum		[mg/g]	% of Sum		
Park	2007	Sulfide	WWTP	Aerobic	15.50	N/D	Dubois, 1956	3.70	N/D	4.19	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	mg/g-VS-Sludge
Park	2007	Sulfide	WWTP	Aerobic	12.40	N/D	Dubois, 1956	2.90	N/D	4.28	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	mg/g-VS-Sludge
Park	2007	Sulfide	WWTP	Aerobic	11.60	N/D	Dubois, 1956	2.70	N/D	4.30	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	mg/g-VS-Sludge
Park	2007	Sulfide	WWTP	Aerobic	13.60	N/D	Dubois, 1956	2.80	N/D	4.86	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	mg/g-VS-Sludge
Park	2008	Sulfide	WWTP	Aerobic	22.20	N/D	Dubois, 1956	10.60	N/D	2.09	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	mg/g-VS-Sludge
Park	2008	Sulfide	WWTP	Aerobic	33.00	N/D	Dubois, 1956	9.70	N/D	3.40	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	mg/g-VS-Sludge
Park	2008	Sulfide	WWTP	Aerobic	11.10	N/D	Dubois, 1956	2.90	N/D	3.83	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	mg/g-VS-Sludge
Park	2008	Sulfide	WWTP	Aerobic	15.50	N/D	Dubois, 1956	3.70	N/D	4.19	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	mg/g-VS-Sludge
Park	2008	Sulfide	WWTP	Aerobic	13.10	N/D	Dubois, 1956	3.50	N/D	3.74	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	mg/g-VS-Sludge
Liang	2010	Base	Lab-Scale Reactor	Biofilm	51.00	65.98%	Gaudy, 1962	8.00	10.35%	6.38	16.00	20.70%	N/D	N/D	Picogreen	2.30	2.98%	N/D	N/D	N/D	N/D	N/D	N/D	77.30	mg/g-VSS-Biofilm
D'Abzac	2010	Centrifuge	Paper-Mill WW	Anaerobic Granular	68.18	20.13%	Dubois, 1956	70.45	20.81%	0.97	190.89	56.38%	<8	N/D	Burton, 1956	9.09	2.68%	Blumenkrantz, 1973	6.82	2.01%	0.10	N/D	N/D	338.60	mg/g-DW-EPS
D'Abzac	2010	Centrifuge	Distillery WW	Anaerobic Granular	77.27	37.78%	Dubois, 1956	31.82	15.56%	2.43	68.18	33.33%	<8	N/D	Burton, 1956	27.27	13.33%	Blumenkrantz, 1973	4.55	2.22%	0.14	N/D	N/D	204.53	mg/g-DW-EPS
D'Abzac	2010	Centrifuge	Sulfate/Ethanol-Rich WW	Anaerobic Granular	9.09	3.57%	Dubois, 1956	31.82	12.50%	0.29	177.26	69.64%	<8	N/D	Burton, 1956	36.36	14.29%	Blumenkrantz, 1973	9.09	3.57%	0.29	N/D	N/D	254.52	mg/g-DW-EPS
D'Abzac	2010	Centrifuge	Brandy Vinasse WW	Anaerobic Granular	9.09	10.26%	Dubois, 1956	2.27	2.56%	4.00	77.27	87.18%	<8	N/D	Burton, 1956	0.00	0.00%	Blumenkrantz, 1973	4.55	5.13%	2.00	N/D	N/D	88.63	mg/g-DW-EPS
Liu	2002	Centrifuge	Municipal WWTP	Acidogenic	4.40	12.25%	Gaudy, 1962	23.70	65.98%	0.19	1.90	5.29%	N/D	N/D	Sun, 1999	0.02	0.06%	Kintner, 1982	1.00	2.78%	0.04	5.90	16.43%	35.92	mg/g-VS-Sludge
Liang	2010	Centrifuge	Lab-Scale Reactor	Biofilm	7.00	56.91%	Gaudy, 1962	2.00	16.26%	3.50	3.00	24.39%	N/D	N/D	Picogreen	0.30	2.44%	N/D	N/D	N/D	N/D	N/D	N/D	12.30	mg/g-VSS-Biofilm
Liu	2002	Centrifuge	Municipal WWTP	Methanogenic	5.80	37.35%	Gaudy, 1962	4.10	26.40%	1.41	3.10	19.96%	N/D	N/D	Sun, 1999	0.03	0.19%	Kintner, 1982	0.30	1.93%	0.07	2.50	16.10%	15.53	mg/g-VS-Sludge
D'Abzac	2010	CER	Paper-Mill WW	Anaerobic Granular	93.17	32.54%	Dubois, 1956	74.99	26.19%	1.24	109.08	38.10%	<8	N/D	Burton, 1956	9.09	3.17%	Blumenkrantz, 1973	6.82	2.38%	0.09	N/D	N/D	286.34	mg/g-DW-EPS
D'Abzac	2010	CER	Sulfate/Ethanol-Rich WW	Anaerobic Granular	47.72	29.58%	Dubois, 1956	65.90	40.85%	0.72	43.18	26.76%	<8	N/D	Burton, 1956	4.55	2.82%	Blumenkrantz, 1973	13.64	8.45%	0.21	N/D	N/D	161.35	mg/g-DW-EPS
D'Abzac	2010	CER	Distillery WW	Anaerobic Granular	140.90	65.61%	Dubois, 1956	9.09	4.23%	15.50	59.09	27.51%	<8	N/D	Burton, 1956	5.68	2.65%	Blumenkrantz, 1973	3.41	1.59%	0.38	N/D	N/D	214.75	mg/g-DW-EPS
D'Abzac	2010	CER	Brandy Vinasse WW	Anaerobic Granular	61.36	42.19%	Dubois, 1956	13.64	9.38%	4.50	70.45	48.44%	<8	N/D	Burton, 1956	0.00	0.00%	Blumenkrantz, 1973	6.82	4.69%	0.50	N/D	N/D	145.44	mg/g-DW-EPS
Liu	2002	CER	Municipal WWTP	Acidogenic	6.20	11.04%	Gaudy, 1962	38.70	68.89%	0.16	3.00	5.34%	N/D	N/D	Sun, 1999	0.08	0.14%	Kintner, 1982	2.20	3.92%	0.06	8.20	14.60%	56.18	mg/g-VS-Sludge
Jahn	1995	CER	Sewer	Biofilm	351.00	54.50%	Gaudy, 1962	46.00	7.14%	7.63	221.00	34.32%	N/D	N/D	Brunk, 1979	26.00	4.04%	Kintner, 1982	11.00	1.71%	0.24	N/D	N/D	644.00	mg/g-TOC-EPS
Jahn	1995	CER	Sewer	Biofilm	154.00	32.70%	Gaudy, 1962	12.00	2.55%	12.83	293.00	62.21%	N/D	N/D	Brunk, 1979	12.00	2.55%	Kintner, 1982	6.00	1.27%	0.50	N/D	N/D	471.00	mg/g-TOC-EPS
Liang	2010	CER	Lab-Scale Reactor	Biofilm	43.00	60.39%	Gaudy, 1962	9.00	12.64%	4.78	18.00	25.28%	N/D	N/D	Picogreen	1.20	1.69%	N/D	N/D	N/D	N/D	N/D	N/D	71.20	mg/g-VSS-Biofilm
Liu	2002	CER	Municipal WWTP	Methanogenic	10.60	36.36%	Gaudy, 1962	7.90	27.10%	1.34	5.50	18.87%	N/D	N/D	Sun, 1999	0.05	0.17%	Kintner, 1982	0.90	3.09%	0.11	5.10	17.50%	29.15	mg/g-VS-Sludge
Comte (a)	2006	EDTA	WWTP	Aerobic	N/D	N/D	Dubois, 1956	24.00	64.86%		N/D	N/D	5.00	13.51%	Burton, 1956	8.00	21.62%	Blumenkrantz, 1973	6.00	16.22%	0.25	N/D	N/D	37.00	mg/g-VS-Sludge
Comte (a)	2006	EDTA	WWTP	Aerobic	N/D	N/D	Dubois, 1956	31.00	81.58%		N/D	N/D	5.00	13.16%	Burton, 1956	2.00	5.26%	Blumenkrantz, 1973	19.00	50.00%	0.61	N/D	N/D	38.00	mg/g-VS-Sludge
D'Abzac	2010	EDTA	Distillery WW	Anaerobic Granular	11.36	40.00%	Dubois, 1956	3.41	12.00%	3.33	11.36	40.00%	<8	N/D	Burton, 1956	2.27	8.00%	Blumenkrantz, 1973	0.00	0.00%	0.00	N/D	N/D	28.41	mg/g-DW-EPS
D'Abzac	2010	EDTA	Paper-Mill WW	Anaerobic Granular	4.55	6.25%	Dubois, 1956	11.36	15.63%	0.40	54.54	75.00%	<8	N/D	Burton, 1956	2.27	3.13%	Blumenkrantz, 1973	2.27	3.13%	0.20	N/D	N/D	72.72	mg/g-DW-EPS
D'Abzac	2010	EDTA	Brandy Vinasse WW	Anaerobic Granular	22.73	39.22%	Dubois, 1956	7.95	13.73%	2.86	27.27	47.06%	<8	N/D	Burton, 1956	0.00	0.00%	Blumenkrantz, 1973	3.41	5.88%	0.43	N/D	N/D	57.95	mg/g-DW-EPS
Liu	2002	EDTA	Municipal WWTP	Acidogenic	6.50	6.33%	Gaudy, 1962	41.70	40.64%	0.16	15.90	15.49%	N/D	N/D	Sun, 1999	0.22	0.21%	Kintner, 1982	2.30	2.24%	0.06	38.30	37.32%	102.62	mg/g-VS-Sludge
Liu	2002	EDTA	Municipal WWTP	Aerobic	22.90	15.83%	Gaudy, 1962	12.40	8.57%	1.85	59.20	40.92%	N/D	N/D	Sun, 1999	0.47	0.32%	Kintner, 1982	2.10	1.45%	0.17	49.70	34.35%	144.67	mg/g-VS-Sludge
Liang	2010	EDTA	Lab-Scale Reactor	Aerobic	73.00	67.41%	Gaudy, 1962	6.00	5.54%	12.17	29.00	26.78%	N/D	N/D	Picogreen	0.30	0.28%	N/D	N/D	N/D	N/D	N/D	N/D	108.30	mg/g-VSS-Biofilm
Liang	2010	EDTA	Lab-Scale Reactor	Biofilm	88.00	74.20%	Gaudy, 1962	7.00	5.90%	12.57	23.00	19.39%	N/D	N/D	Picogreen	0.60	0.51%	N/D	N/D	N/D	N/D	N/D	N/D	118.60	mg/g-VSS-Biofilm
Liu	2002	EDTA	Municipal WWTP	Methanogenic	12.00	16.75%	Gaudy, 1962	6.80	9.49%	1.76	24.30	33.91%	N/D	N/D	Sun, 1999	0.26	0.36%	Kintner, 1982	1.20	1.67%	0.18	28.30	39.49%	71.66	mg/g-VS-Sludge
D'Abzac	2010	Ethanol	Paper-Mill WW	Anaerobic Granular	202.25	39.21%	Dubois, 1956	149.99	29.07%	1.35	149.99	29.07%	<8	N/D	Burton, 1956	13.64	2.64%	Blumenkrantz, 1973	18.18	3.52%	0.12	N/D	N/D	515.86	mg/g-DW-EPS
D'Abzac	2010	Ethanol	Distillery WW	Anaerobic Granular	122.72	47.79%	Dubois, 1956	54.54	21.24%	2.25	45.45	17.70%	<8	N/D	Burton, 1956	34.09	13.27%	Blumenkrantz, 1973	13.64	5.31%	0.25	N/D	N/D	256.79	mg/g-DW-EPS
D'Abzac	2010	Ethanol	Brandy Vinasse WW	Anaerobic Granular	45.45	26.32%	Dubois, 1956	18.18	10.53%	2.50	109.08	63.16%	<8	N/D	Burton, 1956	0.00	0.00%	Blumenkrantz, 1973	15.91	9.21%	0.88	N/D	N/D	172.71	mg/g-DW-EPS
Liu	2002	Formaldehyde	Municipal WWTP	Acidogenic	5.90	10.68%	Gaudy, 1962	39.40	71.35%	0.15	2.50	4.53%	N/D	N/D	Sun, 1999	0.02	0.04%	Kintner, 1982	1.70	3.08%	0.04	7.40	13.40%	55.22	mg/g-VS-Sludge
Liu	2002	Formaldehyde	Municipal WWTP	Methanogenic	11.90	37.50%	Gaudy, 1962	9.70	30.57%	1.23	4.60	14.50%	N/D	N/D	Sun, 1999	0.03	0.09%	Kintner, 1982	0.80	2.52%	0.08	5.50	17.33%	31.73	mg/g-VS-Sludge
D'Abzac	2010	Formaldehyde + Heat	Distillery WW	Anaerobic Granular	306.79	43.83%	Dubois, 1956	52.27	7.47%	5.87	318.15	45.45%	<8	N/D	Burton, 1956	22.73	3.25%	Blumenkrantz, 1973	4.55	0.65%	0.09	N/D	N/D	699.93	mg/g-DW-EPS
D'Abzac	2010	Formaldehyde + Heat	Paper-Mill WW	Anaerobic Granular	127.26	24.26%	Dubois, 1956	87.26	16.64%	1.46	263.61	50.26%	<8	N/D	Burton, 1956	46.36	8.84%	Blumenkrantz, 1973	18.18	3.47%	0.21	N/D	N/D	524.49	mg/g-DW-EPS
D'Abzac	2010	Formaldehyde + Heat	Sulfate/Ethanol-Rich WW	Anaerobic Granular	81.81	15.72%	Dubois, 1956	188.62	36.24%	0.43	188.62	36.24%	<8	N/D	Burton, 1956	61.36	11.79%	Blumenkrantz, 1973	72.72	13.97%	0.39	N/D	N/D	520.40	mg/g-DW-EPS
D'Abzac	2010	Formaldehyde + Heat	Brandy Vinasse WW	Anaerobic Granular	31.82	19.72%	Dubois, 1956	25.00	15.49%	1.27	77.27	47.89%	<8	N/D	Burton, 1956	27.27	16.90%	Blumenkrantz, 1973	18.18	11.27%	0.73	N/D	N/D	161.35	mg/g-DW-EPS
Comte (a)	2006	Formaldehyde + NaOH	WWTP	Aerobic	73.00	37.06%	Dubois, 1956	43.00	21.83%	1.70	74.00	37.56%	1.00	0.51%	Burton, 1956	6.00	3.05%	Blumenkrantz, 1973	52.00	26.40%	1.21	N/D	N/D	197.00	mg/g-VS-Sludge
Comte (a)	2006	Formaldehyde + NaOH	WWTP	Aerobic	107.00	42.13%	Dubois, 1956	53.00	20.87%	2.02	83.00	32.68%	2.00	0.79%	Burton, 1956	9.00	3.54%	Blumenkrantz, 1973	85.00	33.46%	1.60	N/D	N/D	254.00	mg/g-VS-Sludge
D'Abzac	2010	Formaldehyde + NaOH	Distillery WW	Anaerobic Granular	97.72	66.15%	Dubois, 1956	11.36	7.69%	8.60	36.36	24.62%	<8	N/D	Burton, 1956	2.27	1.54%	Blumenkrantz, 1973	0.00	0.00%	0.00	N/D	N/D	147.71	mg/g-DW-EPS
D'Abzac	2010	Formaldehyde + NaOH	Paper-Mill WW	Anaerobic Granular	190.89	42.00%	Dubois, 1956	45.45	10.00%	4.20	215.89	47.50%	<8	N/D	Burton, 1956	2.27	0.50%	Blumenkrantz, 1973	9.09	2.00%	0.20	N/D	N/D	454.50	mg/g-DW-EPS
D'Abzac	2010	Formaldehyde + NaOH	Brandy Vinasse WW	Anaerobic Granular	81.81	52.94%	Dubois, 1956	13.64	8.82%	6.00	59.09	38.24%	<8	N/D	Burton, 1956	0.00	0.00%	Blumenkrantz, 1973	9.09	5.88%	0.67	N/D	N/D	154.53	mg/g-DW-EPS
Liu	2002	Formaldehyde + NaOH	Municipal WWTP	Acidogenic	25.80	14.87%	Gaudy, 1962	110.90	63.94%	0.23	15.10	8.71%	N/D	N/D	Sun, 1999	0.15	0.09%	Kintner, 1982	5.50	3.17%	0.05	21.50	12.40%	173.45	mg/g-VS-Sludge
Liu	2002	Formaldehyde + NaOH	Municipal WWTP	Methanogenic	42.10	42.10%	Gaudy, 1962	19.10	19.10%	2.20	23.30	23.30%	N/D	N/D	Sun, 1999	0.19	0.19%	Kintner, 1982	2.10	2.10%	0.11	15.30	15.30%	99.99	mg/g-VS-Sludge
Liu	2002	Formaldehyde + Sonication	Municipal WWTP	Acidogenic	10.80	11.08%	Gaudy, 1962	71.60	73.47%	0.15	5.00	5.13%	N/D	N/D	Sun, 1999	0.05	0.05%	Kintner, 1982	2.50	2.57%	0.03	10.00	10.26%	97.45	mg/g-VS-Sludge
Liu	2002	Formaldehyde + Sonication	Municipal WWTP	Methanogenic	13.10	36.55%	Gaudy, 1962	12.00	33.48%	1.09	5.60	15.63%	N/D	N/D	Sun, 1999	0.04	0.11%	Kintner, 1982	1.00	2.79%	0.08	5.10	14.23%	35.84	mg/g-VS-Sludge
D'Abzac	2010	Heat	Distillery WW	Anaerobic Granular	204.53	43.06%	Dubois, 1956	40.91	8.61%	5.00	202.25	42.58%	<8	N/D	Burton, 1956	27.27	5.74%	Blumenkrantz, 1973	4.55	0.96%	0.11	N/D	N/D	474.95	mg/g-DW-EPS
D'Abzac	2010	Heat	Paper-Mill WW	Anaerobic Granular	116.35	27.21%	Dubois, 1956	56.81	13.28%	2.05	240.89	56.32%	<8	N/D	Burton, 1956	13.64	3.19%	Blumenkrantz, 1973	9.09	2.13%	0.16	N/D	N/D	427.68	mg/g-DW-EPS
D'Abzac	2010	Heat	Sulfate/Ethanol-Rich WW	Anaerobic Granular	25.00	8.27%	Dubois, 1956	45.45	15.04%	0.55	188.62	62.41%	<8	N/D	Burton, 1956	43.18	14.29%	Blumenkrantz, 1973	9.09	3.01%	0.20	N/D	N/D	302.24	mg/g-DW-EPS
D'Abzac	2010	Heat	Brandy Vinasse WW	Anaerobic Granular	34.09	22.39%	Dubois, 1956	9.09	5.97%	3.75	109.08	71.64%	<8	N/D	Burton, 1956	0.00	0.00%	Blumenkrantz, 1973	6.82	4.48%	0.75	N/D	N/D	152.26	mg/g-DW-EPS

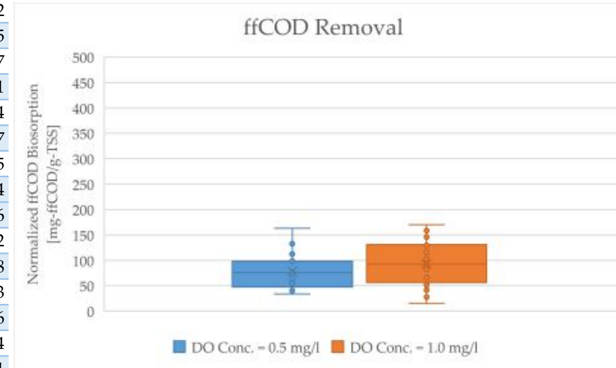
Author	Year	Extraction Method	EPS Source	Sludge Type	Proteins		Carbohydrates/Polysaccharides			P/C	Humic Acids		Lipids		Nucleic Acids/DNA			Uronic Acids			U/C	Unknown		Sum	Unit
					[mg/g]	% of Sum	Method	[mg/g]	% of Sum		[mg/g]	% of Sum	[mg/g]	% of Sum	Method	[mg/g]	% of Sum	Method	[mg/g]	% of Sum		[mg/g]	% of Sum		
Liang	2010	LB-EPS	Lab-Scale Reactor	Biofilm	7.20	63.72%	Gaudy, 1962	2.60	23.01%	2.77	0.70	6.19%	N/D	N/D	Picogreen	0.80	7.08%	N/D	N/D	N/D	N/D	N/D	N/D	11.30	mg/g-VSS-Biofilm
Liang	2010	Pellets	Lab-Scale Reactor	Biofilm	132.00	67.35%	Gaudy, 1962	28.00	14.29%	4.71	15.00	7.65%	N/D	N/D	Picogreen	21.00	10.71%	N/D	N/D	N/D	N/D	N/D	N/D	196.00	mg/g-VSS-Biofilm
Liang	2010	SMP	Lab-Scale Reactor	Biofilm	1.30	24.53%	Gaudy, 1962	1.1	20.75%	1.18	2.20	41.51%	N/D	N/D	Picogreen	0.7	13.21%	N/D	N/D	N/D	N/D	N/D	N/D	5.30	mg/g-VSS-Biofilm
D'Abzac	2010	Sonication	Paper-Mill WW	Anaerobic Granular	86.36	24.36%	Dubois, 1956	68.18	19.23%	1.27	190.89	53.85%	<8	N/D	Burton, 1956	9.09	2.56%	Blumenkrantz, 1973	4.55	1.28%	0.07	N/D	N/D	354.51	mg/g-DW-EPS
D'Abzac	2010	Sonication	Distillery WW	Anaerobic Granular	99.99	46.81%	Dubois, 1956	34.09	15.96%	2.93	59.09	27.66%	<8	N/D	Burton, 1956	20.45	9.57%	Blumenkrantz, 1973	4.55	2.13%	0.13	N/D	N/D	213.62	mg/g-DW-EPS
D'Abzac	2010	Sonication	Brandy Vinasse WW	Anaerobic Granular	9.09	11.43%	Dubois, 1956	6.82	8.57%	1.33	63.63	80.00%	<8	N/D	Burton, 1956	0.00	0.00%	Blumenkrantz, 1973	3.41	4.29%	0.50	N/D	N/D	79.54	mg/g-DW-EPS
Liang	2010	Sonication	Lab-Scale Reactor	Biofilm	94.00	71.43%	Gaudy, 1962	14.00	10.64%	6.71	21.00	15.96%	N/D	N/D	Picogreen	2.60	1.98%	N/D	N/D	N/D	N/D	N/D	N/D	131.60	mg/g-VSS-Biofilm
Guibaud	2003	Sonication + CER	WWTP	Aerobic	261.00	39.13%	Dubois, 1956	142.00	21.29%	1.84	245.00	36.73%	13.00	1.95%	Burton, 1956	6.00	0.90%	Blumenkrantz, 1973	184.00	27.59%	1.30	N/D	N/D	667.00	mg/g-DW-EPS
Guibaud	2003	Sonication + CER	WWTP	Aerobic	229.00	35.56%	Dubois, 1956	143.00	22.20%	1.60	206.00	31.99%	12.00	1.86%	Burton, 1956	54.00	8.39%	Blumenkrantz, 1973	188.00	29.19%	1.31	N/D	N/D	644.00	mg/g-DW-EPS
Guibaud	2003	Sonication + CER	Lab-Scale Plant	Aerobic	293.00	35.64%	Dubois, 1956	187.00	22.75%	1.57	275.00	33.45%	23.00	2.80%	Burton, 1956	44.00	5.35%	Blumenkrantz, 1973	267.00	32.48%	1.43	N/D	N/D	822.00	mg/g-DW-EPS
Guibaud	2003	Sonication + CER	WWTP	Aerobic	261.00	32.79%	Dubois, 1956	199.00	25.00%	1.31	241.00	30.28%	19.00	2.39%	Burton, 1956	76.00	9.55%	Blumenkrantz, 1973	377.00	47.36%	1.89	N/D	N/D	796.00	mg/g-DW-EPS
Guibaud	2003	Sonication + CER	Lab-Scale Plant	Aerobic	171.00	38.78%	Dubois, 1956	94.00	21.32%	1.82	151.00	34.24%	7.00	1.59%	Burton, 1956	18.00	4.08%	Blumenkrantz, 1973	247.00	56.01%	2.63	N/D	N/D	441.00	mg/g-DW-EPS
Guibaud	2003	Sonication + CER	WWTP	Aerobic	95.00	35.32%	Dubois, 1956	70.00	26.02%	1.36	76.00	28.25%	5.00	1.86%	Burton, 1956	23.00	8.55%	Blumenkrantz, 1973	272.00	101.12%	3.89	N/D	N/D	269.00	mg/g-DW-EPS
D'Abzac	2010	Sonication + CER	Paper-Mill WW	Anaerobic Granular	95.45	34.43%	Dubois, 1956	59.09	21.31%	1.62	113.63	40.98%	<8	N/D	Burton, 1956	9.09	3.28%	Blumenkrantz, 1973	6.82	2.46%	0.12	N/D	N/D	277.25	mg/g-DW-EPS
D'Abzac	2010	Sonication + CER	Distillery WW	Anaerobic Granular	188.62	68.60%	Dubois, 1956	13.64	4.96%	13.83	63.63	23.14%	<8	N/D	Burton, 1956	9.09	3.31%	Blumenkrantz, 1973	2.27	0.83%	0.17	N/D	N/D	274.97	mg/g-DW-EPS
D'Abzac	2010	Sonication + CER	Brandy Vinasse WW	Anaerobic Granular	59.09	38.24%	Dubois, 1956	13.64	8.82%	4.33	81.81	52.94%	<8	N/D	Burton, 1956	0.00	0.00%	Blumenkrantz, 1973	9.09	5.88%	0.67	N/D	N/D	154.53	mg/g-DW-EPS

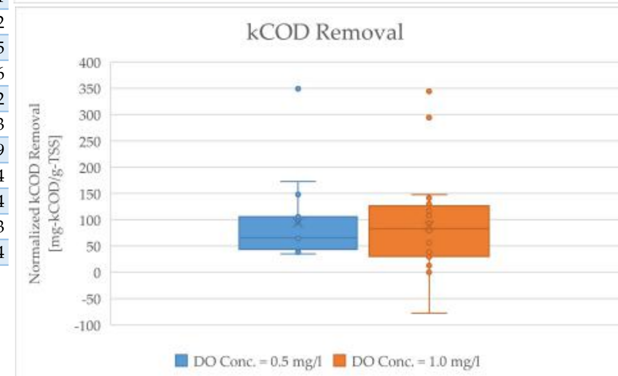
Date	WWTP	Sample	Extraction Time [h]	P [mg/l]	P/T	P/C	C [mg/l]	C/T	H [mg/l]	H/T	H/C	D [mg/l]	D/T	D/C	U [mg/l]	U/T	U/C	T [mg/l]	VDS [mg/l]	T/TVDS	Comment
9-Jul-19	Honouliuli	EPS	0.75	252.0938	0.600402024	6.604293289	38.1712	0.090910866	115.1203	0.274177553	3.015894182	9.24	0.02200655	0.242067318	5.2497	0.012503007	0.137530389	419.875	-	-	-
16-Jul-19	Honouliuli	EPS	0.75	268.8442	0.54303282	5.498567294	48.8935	0.098758966	160.7914	0.324779212	3.288604825	10.4	0.021006744	0.212707211	6.15	0.012422257	0.125783591	495.0791	-	-	Lipid absorption 0.004
17-Jul-19	Wahiawa	EPS	0.75	33.5008	0.385652237	2.568981251	13.0405	0.150118744	29.0692	0.334636845	2.229147655	6.2	0.07137274	0.475441893	5.0574	0.058219434	0.387822553	86.8679	-	-	-
18-Jul-19	East Honolulu	EPS	0.75	232.8308	0.485131681	3.426900258	67.9421	0.141565743	149.359	0.311207893	2.198327694	23	0.047923336	0.338523537	6.8013	0.014171347	0.100104354	479.9332	-	-	Lipid absorption -0.005, used old carb standard
22-Jul-19	Honouliuli	EPS	0.75	270.5193	0.568704481	5.145104416	52.578	0.110533127	136.2934	0.286525461	2.592213473	10.4	0.021863603	0.197801362	5.8857	0.012373328	0.111942257	475.6764	-	-	Lipid absorption -0.002
23-Jul-19	East Honolulu	EPS	0.75	208.5427	0.516032712	4.557822222	45.7549	0.11321914	128.8793	0.318907996	2.816732197	14.7	0.036374713	0.321277065	6.25	0.015465439	0.136597392	404.1269	-	-	Lipid absorption 0.002
24-Jul-19	Wahiawa	EPS	0.75	134.0034	0.601064665	5.777951208	23.1922	0.1040273	55.516	0.249013875	2.393735825	6.6	0.029603926	0.284578436	3.6318	0.016290233	0.156595752	222.9434	-	-	Lipid absorption -0.006
29-Jul-19	Honouliuli	EPS	0.75	180.067	0.456593946	4.758566196	37.8406	0.095952	161.9048	0.410540251	4.278600234	9.96	0.025255464	0.263209357	4.5977	0.011658338	0.121501773	394.3701	-	-	Lipids not measured, total from lyophilization: ~2000 mg/l
30-Jul-19	East Honolulu	EPS	0.75	177.1357	0.568028099	4.410387095	40.1633	0.128793253	77.5261	0.24860603	1.930272164	9.76	0.03129778	0.24300792	7.2581	0.023274838	0.180714732	311.8432	-	-	Extraction & Characterization performed in duplicate
31-Jul-19	Wahiawa	EPS	0.75	105.5276	0.471852316	5.97988338	17.6471	0.078906608	82.6087	0.369373571	4.681148744	13.2	0.059022005	0.747998255	4.662	0.020845499	0.264179384	223.6454	-	-	Total from lyophilization: 1440 mg/l
1-Aug-19	Waimanalo	EPS	0.75	168.3417	0.698871703	6.990121581	24.0828	0.099979907	36.4444	0.151299173	1.513295796	8.76	0.036367199	0.363745079	3.2475	0.013482018	0.134847277	240.8764	-	-	Total from lyophilization: 1060 mg/l
6-Aug-19	East Honolulu	EPS	0.75	153.2663	0.536785604	5.006870034	30.6112	0.107209814	85.9406	0.300990347	2.807488762	8.68	0.030400023	0.283556345	7.028	0.024614212	0.22958917	285.5261	-	-	Total from lyophilization: 2100 mg/l
7-Aug-19	Wahiawa	EPS	0.75	123.9531	0.656423469	7.643028031	16.2178	0.085885262	31.0791	0.164586853	1.916357336	11.7	0.061960165	0.72142954	5.881	0.031144251	0.36262625	188.831	-	-	-
14-Aug-19	Wahiawa	EPS	0.75	96.3149	0.781903083	11.81763414	8.1501	0.066164096	8.033	0.065213456	0.985632078	7.14	0.057963908	0.87606287	3.5421	0.028755456	0.434608164	123.1801	-	-	-
15-Aug-19	Waimanalo	EPS	0.75	210.2178	0.644842647	7.606169811	27.6378	0.084778892	74.5973	0.228827056	2.699104126	8.98	0.027546131	0.324917323	4.5657	0.014005275	0.165197664	325.9986	-	-	-
21-Aug-19	Wahiawa	EPS	0.75	189.2797	0.60605557	11.98101694	15.7983	0.050584652	93.9929	0.300956313	5.949557864	7	0.022413333	0.443085648	6.2432	0.019990132	0.39518176	312.3141	-	-	-
23-Aug-19	Waimanalo	EPS	0.75	194.3049	0.664372934	6.561539475	29.6127	0.1012526	58.567	0.20025398	1.977766296	6.84	0.023387526	0.230981977	3.139	0.01073296	0.106001817	292.4636	-	-	-
29-Aug-19	Waimanalo	EPS	0.75	150.7538	0.561135837	4.839375311	31.1515	0.115952122	76.1905	0.283596301	2.445805178	7.42	0.027618726	0.238190777	3.1425	0.011697014	0.100877967	268.6583	-	-	-
30-Aug-19	Waimanalo	EPS	4	221.943	0.503527983	4.373286936	50.7497	0.115137193	152.4242	0.345808834	3.003450267	11.1	0.025182865	0.218720505	4.559	0.010343124	0.089833043	440.7759	-	-	-
30-Aug-19	Waimanalo	EPS	0.75	176.7169	0.577739948	5.282542672	33.453	0.109367777	85.1515	0.278385504	2.545406989	6.64	0.021708129	0.19848743	3.9148	0.012798642	0.117023884	305.8762	-	-	Humic blind standard not measured
5-Sep-19	Waimanalo	EPS	0.75	221.1055	0.667105056	7.178400403	30.8015	0.092932272	67.54	0.203777272	2.192750353	7.58	0.02286988	0.246091911	4.4133	0.01331552	0.143281983	331.4403	-	-	-
11-Sep-19	Waimanalo	EPS	0.75	199.33	0.632762515	6.237795414	31.9552	0.101440088	72.0351	0.228671605	2.254252829	7.52	0.023871841	0.235329461	4.1752	0.013253951	0.130657921	315.0155	-	-	-
13-Sep-19	Wahiawa	EPS	4	209.3802	0.557767122	5.467145718	38.2979	0.102021631	102.1157	0.272025627	2.666352463	19.5	0.051945976	0.509166299	6.0962	0.016239644	0.159178441	375.39	490	0.766102041	-
13-Sep-19	Wahiawa	EPS	24	297.3199	0.574568402	5.463099445	54.4233	0.105172605	130.0423	0.251305737	2.389460029	30.2	0.058361266	0.554909386	5.481	0.01059199	0.100710541	517.4665	625	0.8279464	-
13-Sep-19	Wahiawa	EPS	0.75	111.3903	0.729136311	10.36902612	10.7426	0.070318688	19.9158	0.13036443	1.853908737	5.68	0.037180026	0.52873606	5.0415	0.033000546	0.469299797	152.7702	260	0.587577692	-
16-Sep-19	Honouliuli	EPS	0.75	146.5662	0.641854819	6.71579584	21.8241	0.095573903	51.5625	0.225806762	2.362640384	4.54	0.019881943	0.208026906	3.8551	0.016882573	0.176644169	228.3479	310	0.736606129	-
16-Sep-19	Honouliuli	WW (<1.5µm)	-	26.8007	0.22985025	3.546473468	7.557	0.064810932	81.25	0.696822575	10.75162101	0	0	0	0.993	0.008516244	0.13140135	116.6007	-	-	DNA too low to measure
16-Sep-19	Honouliuli	EPS	4	249.5812	0.527856801	7.159385784	34.8607	0.073729342	179.375	0.37937278	5.145479006	4.86	0.010278755	0.139412003	4.143	0.008762322	0.118844429	472.8199	570	0.829508596	Humic standards not measured
16-Sep-19	Honouliuli	EPS	24	446.3987	0.47980735	5.153207951	86.6254	0.093108478	367.1875	0.394667953	4.238797166	24.2	0.026011137	0.279363789	5.9591	0.006405081	0.068791602	930.3707	1075	0.865461116	Humic standards not measured
18-Sep-19	Waimanalo	EPS	4	304.8576	0.632119801	5.637597594	54.0758	0.11212574	98.6737	0.20459913	1.824729361	18.9	0.039188999	0.349509392	5.7711	0.01196633	0.106722416	482.2782	565	0.853589735	-
18-Sep-19	Waimanalo	EPS	24	557.7889	0.516416741	3.309045359	168.5649	0.156062152	291.2467	0.269644433	1.727801577	55.2	0.051105721	0.32747031	7.3134	0.006770953	0.043386257	1080.1139	1325	0.815180302	-
18-Sep-19	Waimanalo	EPS	0.75	144.8911	0.551645615	4.926291488	29.4118	0.111979897	77.8736	0.296489087	2.647699223	6.56	0.024975966	0.223039732	3.916	0.014909434	0.13314384	262.6525	275	0.9551	Carb standard not measured
20-Sep-19	East Honolulu	EPS	0.75	177.5544	0.557661141	4.070481431	43.62	0.137001274	82.0265	0.257628037	1.880479138	7.82	0.02456098	0.179275562	7.3703	0.023148567	0.168966071	318.3912	385	0.82699013	-
20-Sep-19	East Honolulu	EPS	24	544.3886	<0.391827420158	<2.276062379797	>239.18	>0.172151441734	524.7126	<0.377665484514	<2.193797976419	63.6	<0.045776535221	<0.265908520779	17.4769	<0.012579118371	<0.073070072748	>1389.3581	1520	>0.91405138157894	Humic standards not measured, Carb out of bounds
20-Sep-19	East Honolulu	EPS	4	305.6951	0.511419544	3.335822418	91.6401	0.153311382	167.5287	0.280270935	1.828115639	22.4	0.037474588	0.244434478	10.4745	0.017523552	0.114300399	597.7384	655	0.91257771	Humic standards not measured
23-Sep-19	Honouliuli	EPS	0.75	168.3417	0.604557298	5.915942732	28.4556	0.102191202	72.2861	0.259597529	2.540311925	4.94	0.01774078	0.17360379	4.4311	0.015913192	0.155719788	278.4545	-	-	TDS & TVDS negative
23-Sep-19	Honouliuli	EPS	4	278.057	0.616204542	5.337703722	52.093	0.115443751	106.5463	0.236118184	2.045309351	10.2	0.022604309	0.195803659	4.3451	0.009629214	0.083410439	451.2414	-	-	TDS & TVDS negative
23-Sep-19	Honouliuli	EPS	24	422.9481	0.548751386	4.457542233	94.8837	0.123106267	231.8284	0.300784318	2.443290049	14.6	0.018942679	0.153872583	6.4861	0.00841535	0.068358422	770.7463	-	-	TDS & TVDS negative
26-Sep-19	Waimanalo	SMP	-	5.8626	0.194387801	1.252317683	4.6814	0.155222436	19.0058	0.630180409	4.05985389	0.214	0.007095655	0.045712821	0.3955	0.0131137	0.084483274	30.1593	65	0.463989231	-
26-Sep-19	Waimanalo	EPS	4	358.459	0.619171821	5.994367827	59.7993	0.103292264	134.5223	0.232362467	2.249563122	18.6	0.03212807	0.31104043	7.5524	0.013045378	0.126295793	578.933	685	0.845157664	-
26-Sep-19	Waimanalo	EPS	24	690.9548	0.486676792	3.733203806	185.0836	0.130364378	483.8217	0.34078176	2.614071155	48.8	0.034372476	0.263664636	11.0805	0.007804595	0.059867541	1419.7406	1770	0.802113333	-
26-Sep-19	Waimanalo	EPS	0.75	277.2194	0.632055896	5.730692824	48.3745	0.110293103	97.3684	0.221998429	2.012804267	9.14	0.020839057	0.188942521	6.4972	0.014813514	0.134310432	438.5995	480	0.913748958	-

Date	WWTP	Sample	Extraction Time [h]	P [mg/l]	P/T	P/C	C [mg/l]	C/T	H [mg/l]	H/T	H/C	D [mg/l]	D/T	D/C	U [mg/l]	U/T	U/C	T [mg/l]	VDS [mg/l]	T/TVDS	Comment
1-Oct-19	East Honolulu	EPS	0.75	168.3417	0.622408936	4.394713553	38.3055	0.141626736	50.6866	0.187403316	1.323219903	6.64	0.024550039	0.173343254	6.4942	0.024010974	0.169537012	270.468	295	0.916840678	-
1-Oct-19	East Honolulu	EPS	24	439.6985	0.433732595	2.171539354	202.4824	0.199735084	310.9114	0.3066929	1.535498394	46.6	0.045967723	0.230143459	14.0625	0.013871698	0.069450481	1013.7548	1240	0.817544194	-
1-Oct-19	East Honolulu	SMP	-	6.7002	0.539238489	1.485401379	4.5107	0.36302544	0	0	0	0	0	0	1.2144	0.097736071	0.269226506	12.4253	171.4286	0.072480905	Humic negative, DNA too low to measure
1-Oct-19	East Honolulu	EPS	4	256.2814	0.534446458	3.692044169	69.4145	0.144756247	125.8023	0.262346755	1.812334599	19.1	0.039830933	0.275158648	8.9286	0.018619606	0.128627304	479.5268	560	0.856297857	-
3-Oct-19	Wahiawa	EPS	0.75	103.0151	0.68631528	7.90132462	13.0377	0.086860788	23.0978	0.153883975	1.771616159	5.92	0.039440688	0.454067819	5.0282	0.033499268	0.385666183	150.0988	265	0.566410566	Blind Humic standard not measured
3-Oct-19	Wahiawa	EPS	24	394.4724	0.485890214	3.381318558	116.6623	0.143698444	231.9149	0.285660494	1.987916405	57.8	0.071194979	0.495447115	11.0054	0.013555869	0.094335531	811.855	1015	0.799857143	-
3-Oct-19	Wahiawa	EPS	4	180.067	0.598164253	5.318881206	33.8543	0.11246054	62.6478	0.208109617	1.850512343	15.7	0.052153803	0.46375202	8.7636	0.029111788	0.258862242	301.0327	380	0.792191316	-
7-Oct-19	Honouliuli	WW (<1.5μm)	-	32.6633	0.385181333	4.374529578	7.4667	0.088050915	43.7352	0.515746499	5.857366708	0	0	0	0.9346	0.011021252	0.125169084	84.7998	280	0.302856429	DNA too low to measure, Carbohydrate stardard not measured
7-Oct-19	Honouliuli	WWTP DAF (<1.5μm	-	19.263	0.291438842	4.069676547	4.7333	0.071612286	40.8983	0.618769309	8.640546764	0	0	0	1.2016	0.018179563	0.253860943	66.0962	215	0.307424186	DNA too low to measure, Carbohydrate stardard not measured
8-Oct-19	Waimanalo	SMP	-	4.1876	0.198252109	0.932318105	4.4916	0.212644277	11.809	0.559069433	2.629129931	0	0	0	0.6344	0.030034181	0.141241428	21.1226	57.1429	0.369645223	Blind Humic standard and blind humic/protein absorbance not measured, DNA too low to
8-Oct-19	Waimanalo	EPS	4	332.4958	0.55879055	4.08863787	81.3219	0.136669123	152.0639	0.255557725	1.869900974	22.2	0.037309194	0.272989195	6.946	0.011673408	0.085413646	595.0276	725	0.820727724	-
8-Oct-19	Waimanalo	EPS	24	579.5645	0.414213289	2.521094142	229.8861	0.164299017	504.9268	0.360869913	2.196421619	74.4	0.053173493	0.323638532	10.416	0.007444289	0.045309395	1399.1934	1930	0.724970674	-
8-Oct-19	Waimanalo	EPS	0.75	218.593	0.602640621	5.15930392	42.3687	0.116806575	88.191	0.243134405	2.081513004	8.44	0.023268297	0.199203657	5.1326	0.014150102	0.121141314	362.7253	520	0.697548654	Blind Humic standard not measured
15-Oct-19	East Honolulu	EPS	0.75	177.5544	0.557037256	4.031360048	44.0433	0.138176013	84.472	0.265012025	1.917930764	6.08	0.019074641	0.138045968	6.5981	0.020700064	0.149809392	318.7478	400	0.7968695	Blind Humic/protein absorbance not measured
15-Oct-19	East Honolulu	EPS	4	272.1943	0.540763323	3.387034677	80.3636	0.15965686	126.3775	0.251071815	1.572571413	17.5	0.034766923	0.21776028	6.9166	0.01374108	0.086066329	503.352	690	0.729495652	-
15-Oct-19	East Honolulu	SMP	-	18.4255	0.609212162	1.849225705	9.9639	0.329441755	0	0	0	0.1	0.003306353	0.010036231	1.7554	0.058039729	0.176175995	30.2448	205	0.14753561	Blind Humic/protein absorbance not measured
15-Oct-19	East Honolulu	EPS	24	505.8626	<0.438592052703	<1.987317002264	>254.5455	>0.220695567040	331.0668	<0.287040922562	<1.300619339175	45.8	<0.039709431007	<0.179928539298	16.1035	>0.013962026686	>0.063263738702	>1153.3784	1615	>0.71416619195046	Carb out of bounds
17-Oct-19	Wahiawa	EPS	0.75	79.5645	0.623596087	5.997309052	13.2667	0.103979315	24.4944	0.191977729	1.846306919	6.14	0.048122969	0.462812908	4.1242	0.0323239	0.310868566	127.5898	235	0.542935319	Carb standard not measured
17-Oct-19	Wahiawa	SMP	-	5.8626	0.325343929	1.46565	4	0.221979278	7.4157	0.411532933	1.853925	0	0	0	0.7414	0.041143859	0.18535	18.0197	71.4286	0.252275699	Carb standard and humic/protein blind absorbance not measured, DNA too low to
17-Oct-19	Wahiawa	EPS	4	178.392	0.550153149	4.65162123	38.3505	0.11827127	80.454	0.248116628	2.097860523	19.7	0.060753941	0.513683003	7.3623	0.022705012	0.191974029	324.2588	370	0.876375135	-
17-Oct-19	Wahiawa	EPS	24	313.2328	0.491634534	3.649681269	85.8247	0.134706156	165.9521	0.260470115	1.933617012	63.8	0.100137289	0.743375741	8.3157	0.013051907	0.096891687	637.1253	795	0.801415472	-
21-Oct-19	Honouliuli	EPS	0.75	173.3668	0.60664406	4.621943774	37.5095	0.131253016	65.9091	0.230628725	1.75713086	5.12	0.017915873	0.136498754	3.8747	0.013558327	0.103299164	285.7801	390	0.732769487	Blind Humic standard not measured
21-Oct-19	Honouliuli	SMP	-	11.7253	0.483200706	3.272298504	3.5832	0.147664006	8.5859	0.353825739	2.396154276	0	0	0	0.3715	0.01530955	0.103678276	24.2659	65	0.373321538	Blind Humic standard not measured
21-Oct-19	Honouliuli	EPS	4	267.1692	0.574357444	5.216161813	51.2195	0.110111125	123.7584	0.266054464	2.416236004	18.6	0.039986078	0.363142944	4.4148	0.009490889	0.086193735	465.1619	625	0.74425904	-
21-Oct-19	Honouliuli	EPS	24	515.9129	0.475055776	4.168551854	123.7631	0.113961825	389.7987	0.358929044	3.149555077	49.6	0.045671985	0.400765656	6.9302	0.006381371	0.055995689	1086.0049	1450	0.748968897	-
23-Oct-19	Honouliuli	EPS	0.75	242.0436	0.531983832	4.225673149	57.2793	0.125893275	142.3515	0.312872129	2.485217173	8.58	0.018857847	0.149792333	4.7286	0.010392916	0.082553383	454.983	475	0.957858947	-
23-Oct-19	Honouliuli	Float EPS	0.75	206.8677	0.581012501	4.057940112	50.9785	0.143179171	85.2086	0.239318472	1.671461498	9.24	0.025951637	0.181252881	3.7521	0.010538218	0.073601616	356.0469	465	0.765692258	Harvesting of float not ideal
23-Oct-19	Honouliuli	WW (<1.5μm)	-	34.3384	0.373632543	4.244181591	8.0907	0.088034062	48.2933	0.525474353	5.968989086	0.308	0.003351316	0.0380684	0.8738	0.009507727	0.108000544	91.9042	240	0.382934167	Blind absorption not measured
23-Oct-19	Honouliuli	Diluted Lab DAF (<1.	-	0	0	0	6.0143	0.075309129	72.8192	0.911818586	12.1076767	0	0	0	1.028	0.012872285	0.17092596	79.8615	140	0.570439286	DNA too low to measure

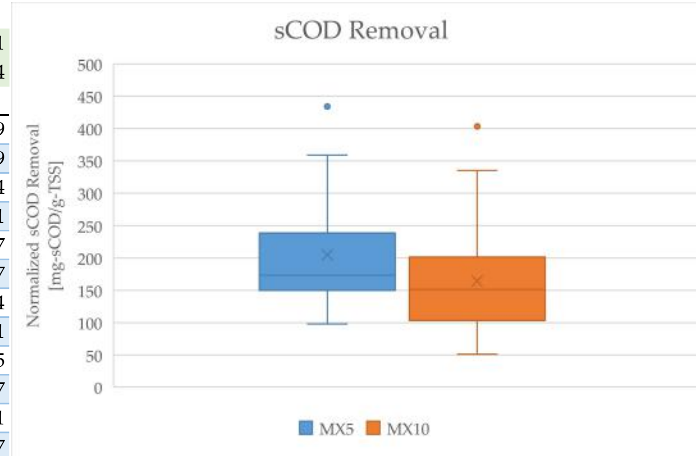
	Normalized sCOD Removal		Normalized ffCOD Removal		Normalized kCOD Removal	
ave	172.7709489	179.5617621	78.67142286	93.14338368	94.09952607	88.46640752
σ	94.66198879	78.49844349	36.10917961	44.86490252	81.07690779	84.4009071
	DO Conc. = 0.5 mg/l	DO Conc. = 1.0 mg/l	DO Conc. = 0.5 mg/l	DO Conc. = 1.0 mg/l	DO Conc. = 0.5 mg/l	DO Conc. = 1.0 mg/l
	140.3524229	91.2	76.12334802	52.8	64.22907489	38.4
	111.8061674	51.67058824	47.57709251	51.81176471	64.22907489	-0.141176471
	103.6900751	280.5109489	57.65224151	170.1459854	46.03783364	110.3649635
	102.2907489	197.7372263	64.22907489	110.3649635	38.06167401	87.37226277
	163.7931034	136.8741949	98.27586207	129.5706312	65.51724138	7.303563761
	152.8735632	176.4238411	47.31800766	41.38686131	105.5555556	135.0369797
	147.5208474	169.9727308	112.4070318	28.94375268	35.11381564	141.0289781
	98.27586207	157.3509934	54.59770115	27.59124088	43.67816092	129.7597525
	173.4782609	88.65671642	132.173913	59.7810219	41.30434783	28.87569452
	230.8040376	83.28358209	82.99686739	160.9489051	147.8071702	-77.66532302
	157.3964497	70.79894644	84.31952663	68.16659511	73.07692308	2.632351339
	129.2899408	403.56	33.72781065	109.44	95.56213018	294.12
	434.2857143	321.48	85.30612245	27.36	348.9795918	294.12
	110.2040816	215.2588235	40.40816327	67.99764706	69.79591837	147.2611765
	335.5029586	211.1111111	162.9585799	149.537037	172.5443787	61.57407407
		195.3295207		102.4509804		92.87854031
		189.1203704		158.3333333		30.78703704
		171.5277778		92.36111111		79.16666667
		113.7735849		57.73584906		56.03773585
		110.3773585		66.22641509		44.1509434
		103.7846837		49.24528302		45.8490566
		95.09433962		14.96062992		344.0944882
		359.0551181		55.23390459		147.3598888
		202.5937934		124.015748		17.71653543
		141.7322835		162.1557293		136.9602176
		299.115947		148.265896		98.84393064
		247.1098266		145.6647399		41.61849711
		187.283237		101.2920775		83.23699422
		184.5290717		132.6589595		13.00578035
		145.6647399		67.12933754		62.33438486
		129.4637224		88.32605042		117.0655462
		205.3915966		104.2285714		107.4857143
		211.7142857		154.3882979		21.54255319
		175.9308511		82.47272727		19.63636364
		102.1090909		111.1764706		83.38235294
		194.5588235		56.98961938		122.8546713
		179.8442907		115.1470588		107.2058824
		222.3529412				

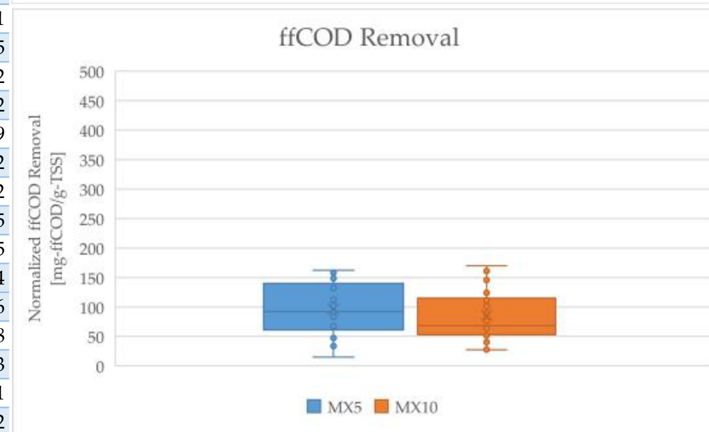


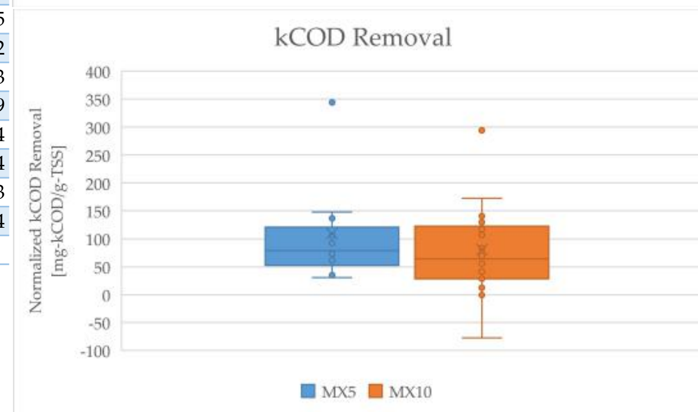




	Normalized sCOD Removal		Normalized ffCOD Removal		Normalized kCOD Removal	
ave	205.2677161	164.5933338	95.66569985	85.71598975	109.6020162	80.6147341
σ	87.64649947	77.81450686	44.21433809	42.19744595	95.07265086	75.64976864
	MX5	MX10	MX5	MX10	MX5	MX10
	163.7931034	140.3524229	98.27586207	76.12334802	65.51724138	64.22907489
	152.8735632	111.8061674	47.31800766	47.57709251	105.5555556	64.22907489
	147.5208474	103.6900751	112.4070318	57.65224151	35.11381564	46.03783364
	98.27586207	102.2907489	54.59770115	64.22907489	43.67816092	38.06167401
	173.4782609	110.2040816	132.173913	40.40816327	41.30434783	69.79591837
	230.8040376	335.5029586	82.99686739	162.9585799	147.8071702	172.5443787
	157.3964497	91.2	84.31952663	52.8	73.07692308	38.4
	129.2899408	51.67058824	33.72781065	51.81176471	95.56213018	-0.141176471
	434.2857143	280.5109489	85.30612245	170.1459854	348.9795918	110.3649635
	211.1111111	197.7372263	149.537037	110.3649635	61.57407407	87.37226277
	195.3295207	136.8741949	102.4509804	129.5706312	92.87854031	7.303563761
	189.1203704	176.4238411	158.3333333	41.38686131	30.78703704	135.0369797
	171.5277778	169.9727308	92.36111111	28.94375268	79.16666667	141.0289781
	359.0551181	157.3509934	14.96062992	27.59124088	344.0944882	129.7597525
	299.115947	88.65671642	162.1557293	59.7810219	136.9602176	28.87569452
	247.1098266	83.28358209	148.265896	160.9489051	98.84393064	-77.66532302
	129.4637224	70.79894644	67.12933754	68.16659511	62.33438486	2.632351339
		403.56		109.44		294.12
		321.48		27.36		294.12
		215.2588235		67.99764706		147.2611765
		113.7735849		57.73584906		56.03773585
		110.3773585		66.22641509		44.1509434
		103.7846837		49.24528302		45.8490566
		95.09433962		55.23390459		147.3598888
		202.5937934		124.015748		17.71653543
		141.7322835		145.6647399		41.61849711
		187.283237		101.2920775		83.23699422
		184.5290717		132.6589595		13.00578035
		145.6647399		88.32605042		117.0655462
		205.3915966		104.2285714		107.4857143
		211.7142857		154.3882979		21.54255319
		175.9308511		82.47272727		19.63636364
		102.1090909		111.1764706		83.38235294
		194.5588235		56.98961938		122.8546713
		179.8442907		115.1470588		107.2058824
		222.3529412				





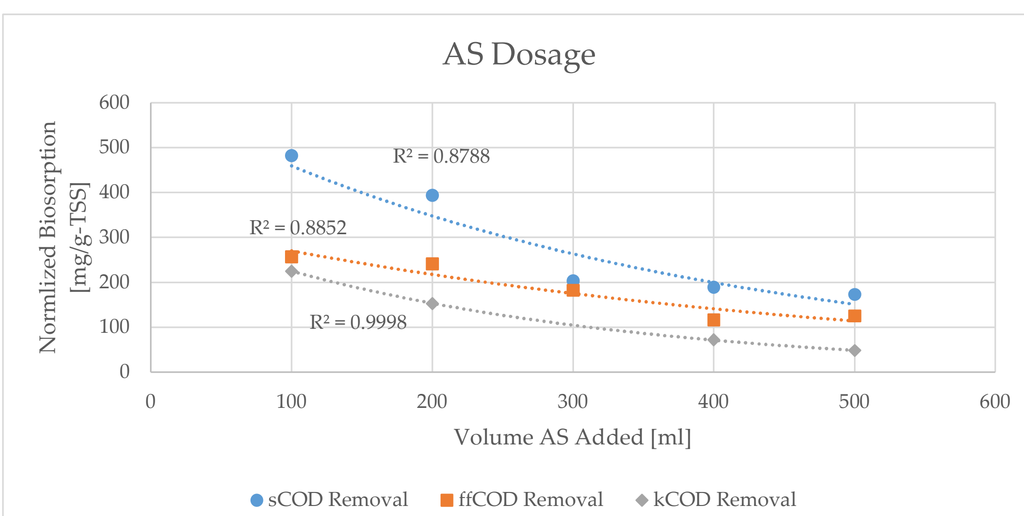


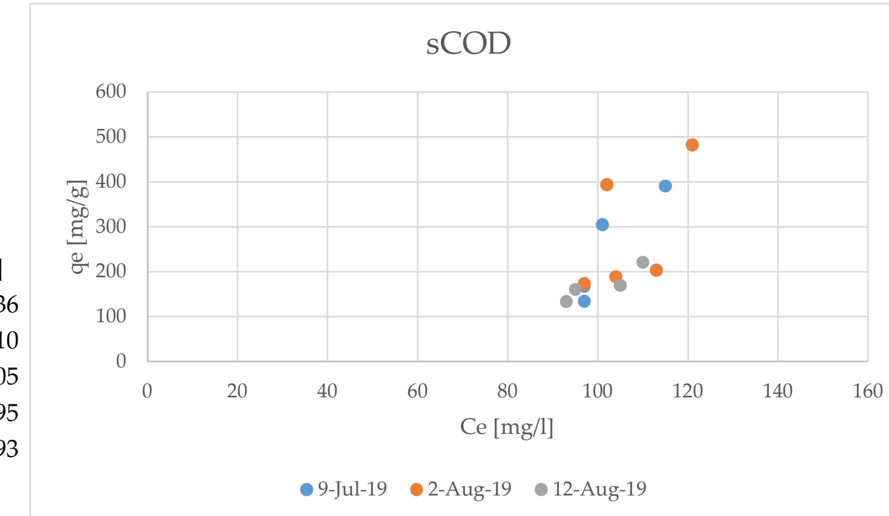
WWTP	Honouliuli
DO Concentration	1.0 mg/l
WW Volume	5l
Contact Time	30min

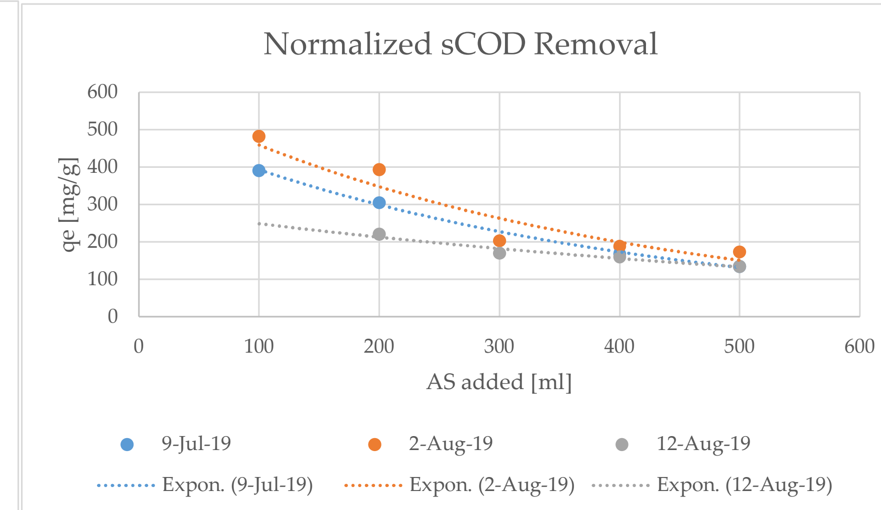
AS Added [ml]	sCOD Removal					
	9-Jul-19		2-Aug-19		12-Aug-19	
	qe [mg/g]	Ce [mg/l]	qe [mg/g]	Ce [mg/l]	qe [mg/g]	Ce [mg/l]
100	390.625	115	482.1429	121		136
200	304.6875	101	393.75	102	220.9821429	110
300		126	203.5714	113	169.6428571	105
400	167.96875	97	188.8393	104	160.7142857	95
500	134.375	97	173.5714	97	133.9285714	93

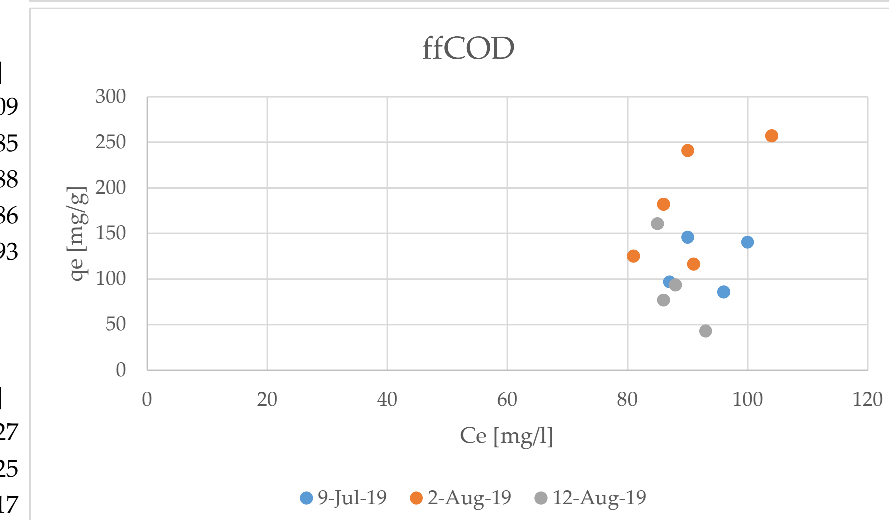
AS Added [ml]	ffCOD Removal					
	9-Jul-19		2-Aug-19		12-Aug-19	
	qe [mg/g]	Ce [mg/l]	qe [mg/g]	Ce [mg/l]	qe [mg/g]	Ce [mg/l]
100		77	257.1429	104		109
200	140.625	100	241.0714	90	160.7142857	85
300	145.8333333	90	182.1429	86	93.75	88
400	85.9375	96	116.5179	91	77.00892857	86
500	96.875	87	125.3571	81	42.85714286	93

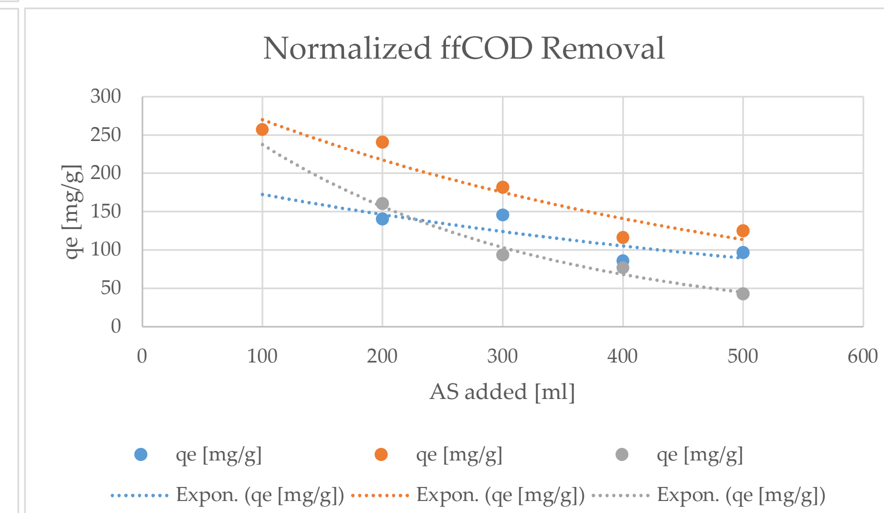
AS Added [ml]	kCOD Removal					
	9-Jul-19		2-Aug-19		12-Aug-19	
	qe [mg/g]	Ce [mg/l]	qe [mg/g]	Ce [mg/l]	qe [mg/g]	Ce [mg/l]
100		38	225	17	93.75	27
200	164.0625	1	152.6786	12	60.26785714	25
300		36		27	75.89285714	17
400	82.03125	1	72.32143	13	83.70535714	9
500	37.5	10	48.21429	16	91.07142857	0

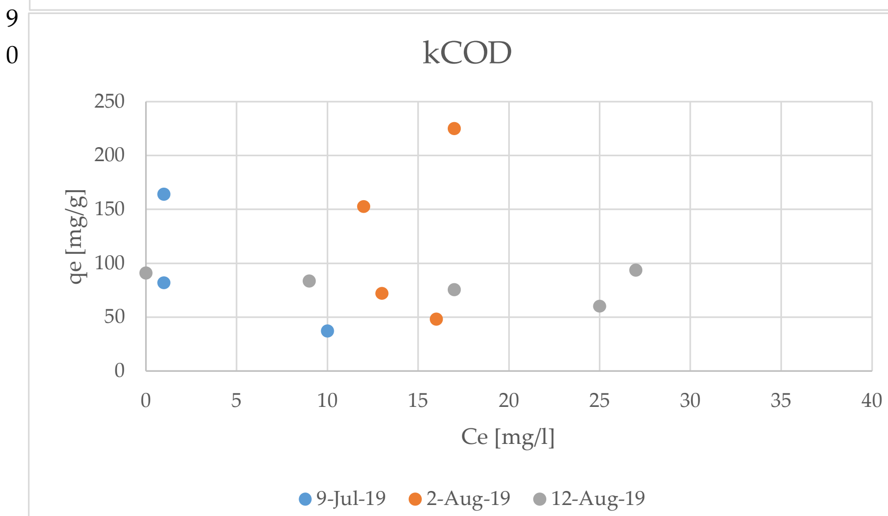


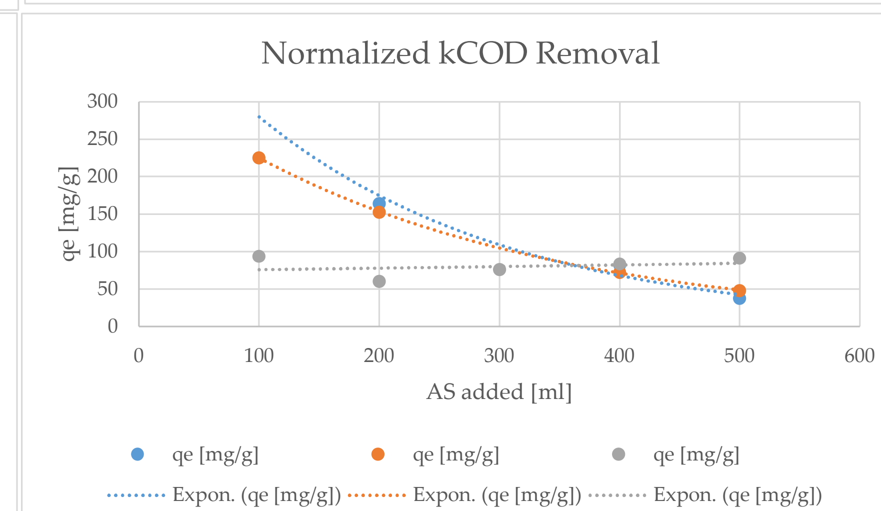






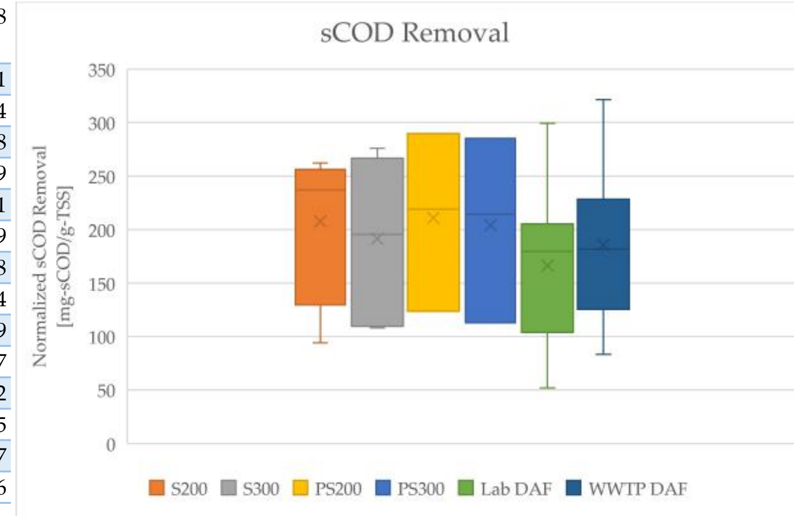






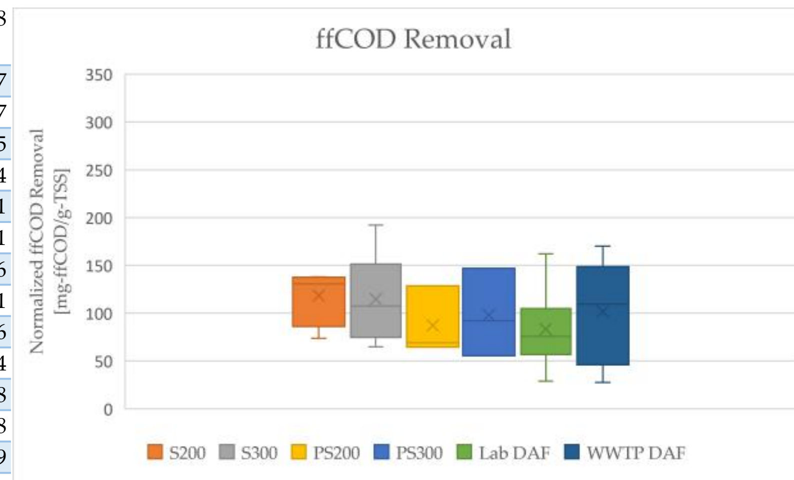
sCOD

	S200	S300	PS200	PS300	Lab DAF	WWTP DAF
ave	207.6711007	191.4432544	210.8759557	204.1716155	166.4786099	185.8332038
	236.1271676	108	289.7080292	285.1094891	195.3295207	211.1111111
	262.1167883	275.9124088	219.3377483	214.5695364	147.5208474	163.7931034
	238.410596	219.3377483	123.5820896	112.8358209	230.8040376	129.2899408
	94.02985075	110.1492537			51.67058824	280.5109489
		263.583815			136.8741949	176.4238411
		171.6763006			169.9727308	83.28358209
					70.79894644	321.48
					215.2588235	111.8061674
					103.6900751	113.7735849
					103.7846837	211.7142857
					205.3915966	222.3529412
					179.8442907	141.7322835
					202.5937934	187.283237
					184.5290717	247.1098266
					299.115947	



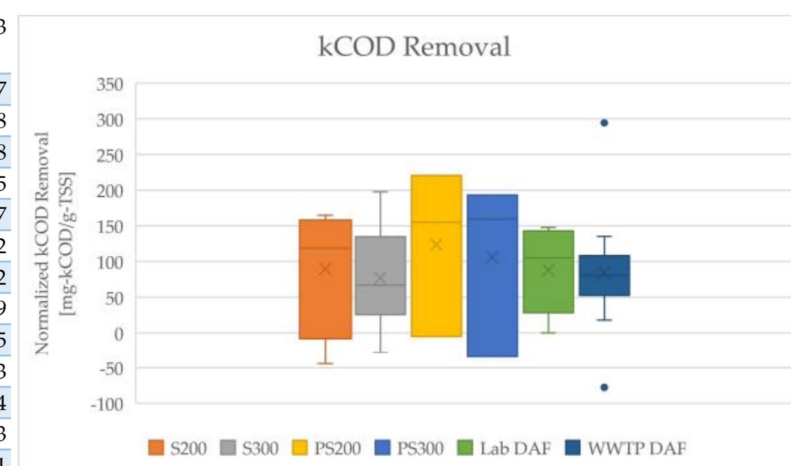
ffCOD

	S200	S300	PS200	PS300	Lab DAF	WWTP DAF
ave	118.2441669	114.6904828	87.37226277	98.10218978	83.2853495	101.7155298
	137.283237	64.8	68.97810219	91.97080292	102.4509804	149.537037
	124.1605839	78.17518248	64.37956204	55.18248175	112.4070318	98.27586207
	73.57664234	105.7664234	128.7591241	147.1532847	82.99686739	33.72781065
	137.9562044	137.9562044			51.81176471	170.1459854
		109.2485549			129.5706312	41.38686131
		192.1965318			28.94375268	160.9489051
					68.16659511	27.36
					67.99764706	47.57709251
					57.65224151	57.73584906
					88.32605042	104.2285714
					56.98961938	115.1470588
					55.23390459	124.015748
					101.2920775	145.6647399
					162.1557293	148.265896



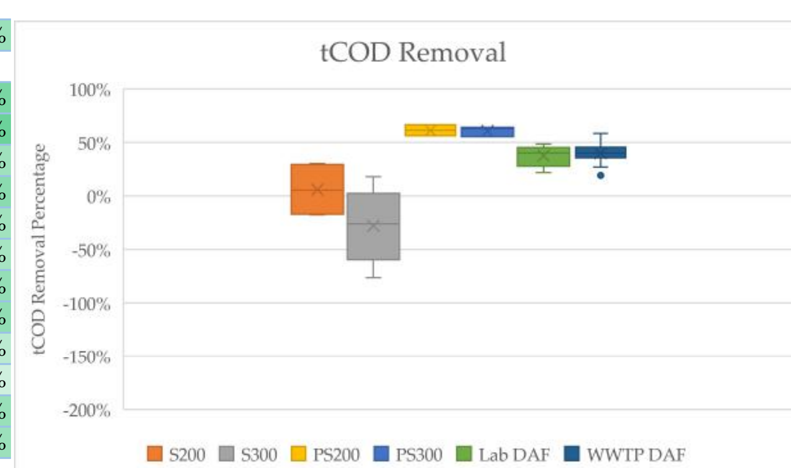
kCOD

	S200	S300	PS200	PS300	Lab DAF	WWTP DAF
ave	89.42693377	76.75277159	123.5036929	106.0694257	87.67139794	84.11767403
	98.84393064	43.2	220.729927	193.1386861	92.87854031	61.57407407
	137.9562044	197.7372263	154.9581863	159.3870547	35.11381564	65.51724138
	164.8339537	113.571325	-5.177034535	-34.31746378	147.8071702	95.56213018
	-43.92635363	-27.80695065			-0.141176471	110.3649635
		62.42774566			7.303563761	135.0369797
		71.38728324			141.0289781	-77.66532302
					2.632351339	294.12
					147.2611765	64.22907489
					46.03783364	56.03773585
					117.0655462	107.4857143
					122.8546713	107.2058824
					147.3598888	17.71653543
					83.23699422	41.61849711
					136.9602176	98.84393064



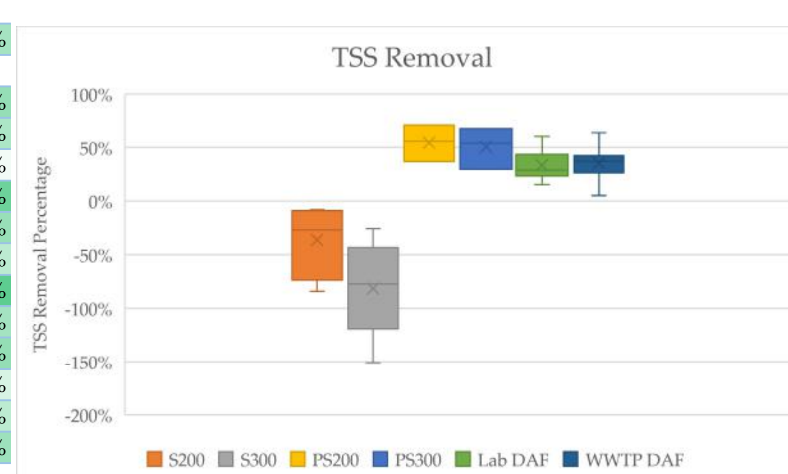
Total COD

	S200	S300	PS200	PS300	Lab DAF	WWTP DAF
ave	6%	-28%	61%	61%	37%	40%
	-18%	-76%	66%	64%	42%	53%
	30%	18%	56%	63%	49%	58%
	26%	-3%		55%	47%	38%
	-16%	-30%			45%	46%
		-54%			39%	37%
		-22%			22%	35%
					30%	42%
					40%	43%
					37%	27%
					24%	19%
					25%	40%
					46%	39%
					41%	



TSS

	S200	S300	PS200	PS300	Lab DAF	WWTP DAF
ave	-36%	-82%	55%	51%	33%	36%
	-42%	-97%	71%	68%	58%	42%
	-8%	-26%	56%	54%	30%	33%
	-11%	-49%	37%	30%	23%	5%
	-84%	-109%			15%	57%
		-151%			45%	41%
		-58%			24%	26%
					22%	64%
					60%	36%
					29%	42%
					28%	16%
					29%	26%
					30%	39%
					42%	



tCOD

ave	32%	30%	57%	54%	60%
	WW S200	WW S300	WW PS200	WW PS300	WW DAF
	24%	24%	59%	52%	59%
	40%	40%	59%	61%	62%
	38%	36%	52%	51%	
	27%	21%			

sCOD

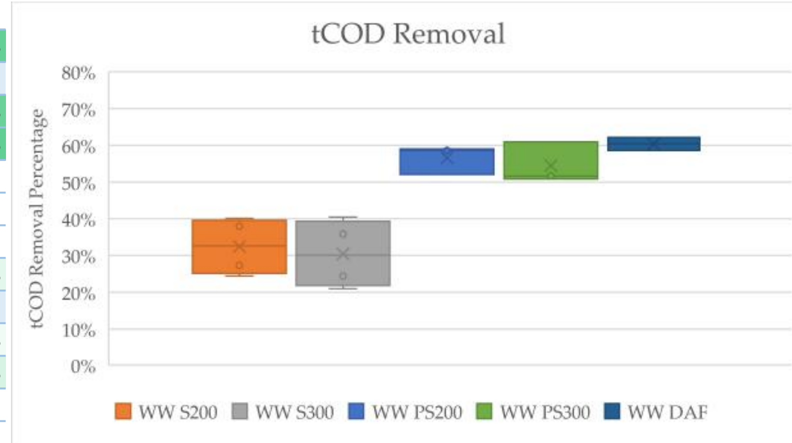
ave	1%	3%	20%	19%	11%
	WW S200	WW S300	WW PS200	WW PS300	WW DAF
	-9%	-7%	19%	16%	6%
	2%	4%	18%	20%	16%
	11%	11%	24%	19%	
	1%	3%			

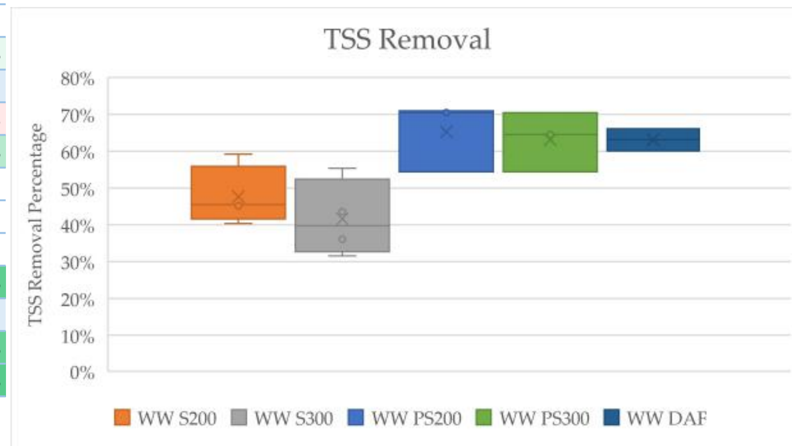
ffCOD

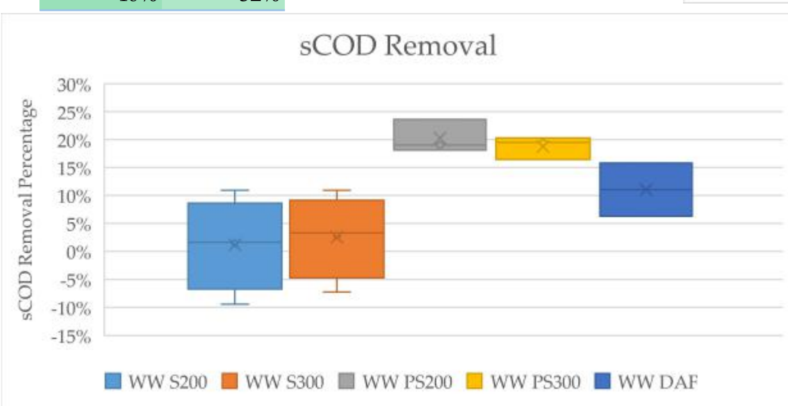
ave	4%	2%	0%	-2%	10%
	WW S200	WW S300	WW PS200	WW PS300	WW DAF
	1%	13%	-11%	-6%	-9%
	6%	-7%	-2%	-7%	28%
	0%	-4%	15%	5%	
	8%	5%			

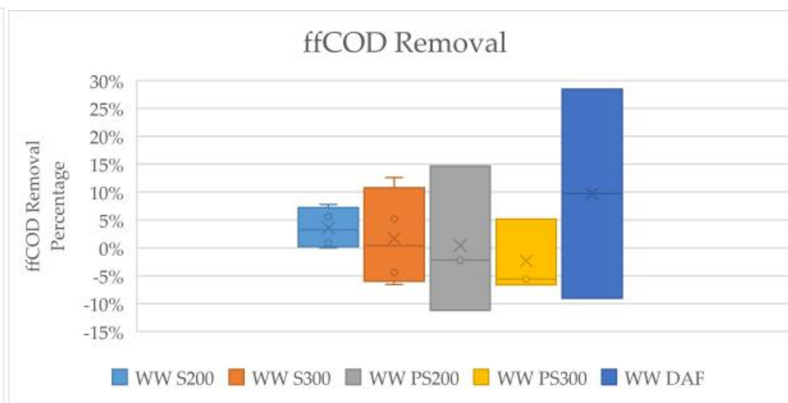
TSS

ave	48%	42%	65%	63%	63%
	WW S200	WW S300	WW PS200	WW PS300	WW DAF
	59%	55%	71%	65%	60%
	45%	44%	70%	70%	66%
	46%	36%	54%	54%	
	40%	32%			

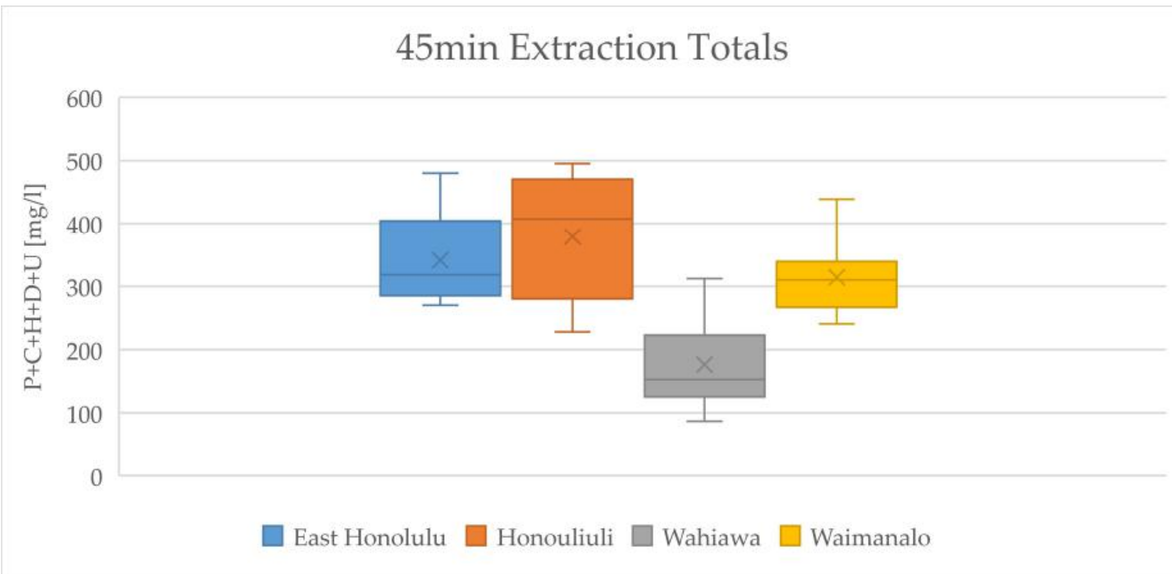




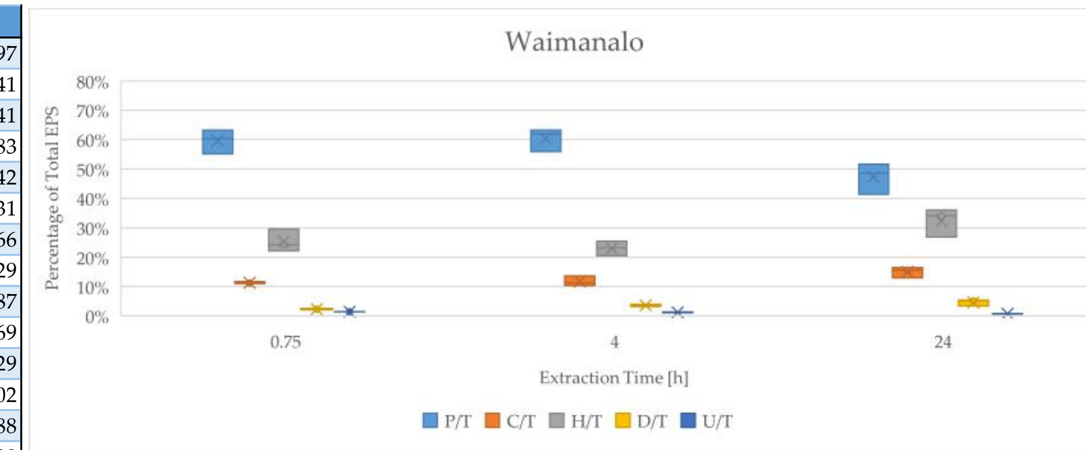


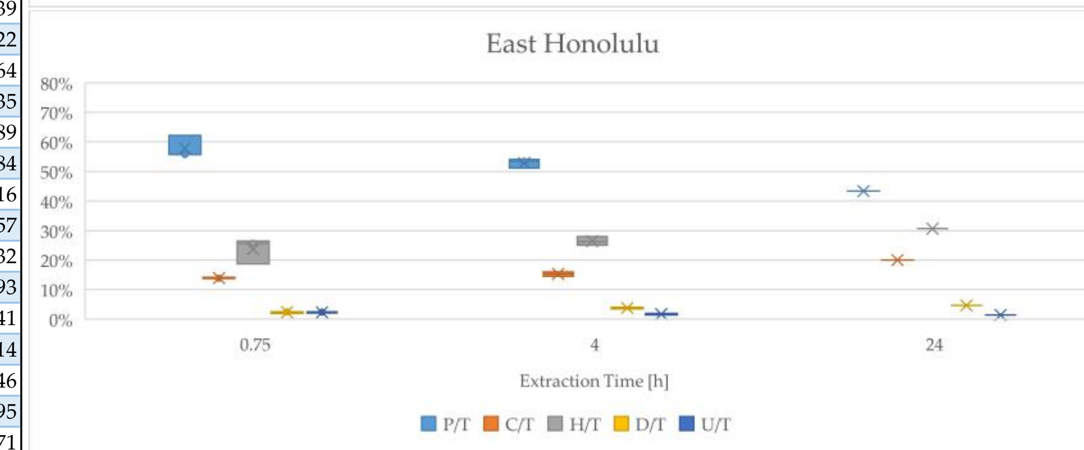


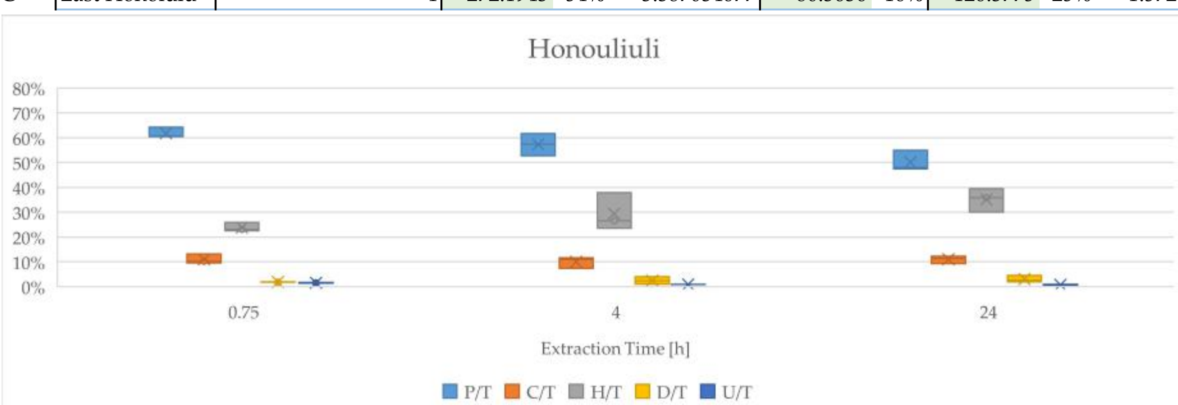
	East Honolulu	Honouliuli	Wahiawa	Waimanalo
	479.9332	419.875	86.8679	240.8764
	404.1269	495.0791	222.9434	325.9986
	311.8432	475.6764	223.6454	292.4636
	285.5261	394.3701	188.831	268.6583
	318.3912	228.3479	123.1801	305.8762
	270.468	278.4545	312.3141	331.4403
	318.7478	285.7801	152.7702	315.0155
		454.983	150.0988	262.6525
			127.5898	438.5995
				362.7253
Average	341.2909143	379.0707625	176.4711889	314.43062

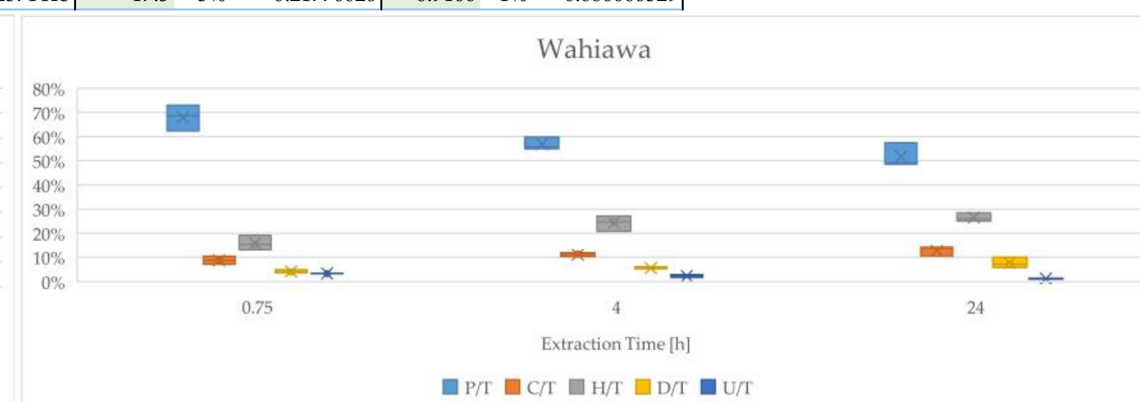


Date	WWTP	Extraction Time [h]	P [mg/l]	P/T	P/C	C [mg/l]	C/T	H [mg/l]	H/T	H/C	D [mg/l]	D/T	D/C	U [mg/l]	U/T	U/C
A	Wahiawa	0.75	111.3903	73%	10.36902612	10.7426	7%	19.9158	13%	1.853908737	5.68	4%	0.52873606	5.0415	3%	0.469299797
A	Wahiawa	4	209.3802	56%	5.467145718	38.2979	10%	102.1157	27%	2.666352463	19.5	5%	0.509166299	6.0962	2%	0.159178441
A	Wahiawa	24	297.3199	57%	5.463099445	54.4233	11%	130.0423	25%	2.389460029	30.2	6%	0.554909386	5.481	1%	0.100710541
B	Wahiawa	0.75	103.0151	69%	7.90132462	13.0377	9%	23.0978	15%	1.771616159	5.92	4%	0.454067819	5.0282	3%	0.385666183
B	Wahiawa	4	180.067	60%	5.318881206	33.8543	11%	62.6478	21%	1.850512343	15.7	5%	0.46375202	8.7636	3%	0.258862242
B	Wahiawa	24	394.4724	49%	3.381318558	116.6623	14%	231.9149	29%	1.987916405	57.8	7%	0.495447115	11.0054	1%	0.094335531
C	Wahiawa	0.75	79.5645	62%	5.997309052	13.2667	10%	24.4944	19%	1.846306919	6.14	5%	0.462812908	4.1242	3%	0.310868566
C	Wahiawa	4	178.392	55%	4.65162123	38.3505	12%	80.454	25%	2.097860523	19.7	6%	0.513683003	7.3623	2%	0.191974029
C	Wahiawa	24	313.2328	49%	3.649681269	85.8247	13%	165.9521	26%	1.933617012	63.8	10%	0.743375741	8.3157	1%	0.096891687
A	Honouliuli	0.75	146.5662	64%	6.71579584	21.8241	10%	51.5625	23%	2.362640384	4.54	2%	0.208026906	3.8551	2%	0.176644169
A	Honouliuli	4	249.5812	53%	7.159385784	34.8607	7%	179.375	38%	5.145479006	4.86	1%	0.139412003	4.143	1%	0.118844429
A	Honouliuli	24	446.3987	48%	5.153207951	86.6254	9%	367.1875	39%	4.238797166	24.2	3%	0.279363789	5.9591	1%	0.068791602
B	Honouliuli	0.75	168.3417	60%	5.915942732	28.4556	10%	72.2861	26%	2.540311925	4.94	2%	0.17360379	4.4311	2%	0.155719788
B	Honouliuli	4	278.057	62%	5.337703722	52.093	12%	106.5463	24%	2.045309351	10.2	2%	0.195803659	4.3451	1%	0.083410439
B	Honouliuli	24	422.9481	55%	4.457542233	94.8837	12%	231.8284	30%	2.443290049	14.6	2%	0.153872583	6.4861	1%	0.068358422
C	Honouliuli	0.75	173.3668	61%	4.621943774	37.5095	13%	65.9091	23%	1.75713086	5.12	2%	0.136498754	3.8747	1%	0.103299164
C	Honouliuli	4	267.1692	57%	5.216161813	51.2195	11%	123.7584	27%	2.416236004	18.6	4%	0.363142944	4.4148	1%	0.086193735
C	Honouliuli	24	515.9129	48%	4.168551854	123.7631	11%	389.7987	36%	3.149555077	49.6	5%	0.400765656	6.9302	1%	0.055995689
A	Waimanalo	0.75	144.8911	55%	4.926291488	29.4118	11%	77.8736	30%	2.647699223	6.56	2%	0.223039732	3.916	1%	0.13314384
A	Waimanalo	4	304.8576	63%	5.637597594	54.0758	11%	98.6737	20%	1.824729361	18.9	4%	0.349509392	5.7711	1%	0.106722416
A	Waimanalo	24	557.7889	52%	3.309045359	168.5649	16%	291.2467	27%	1.727801577	55.2	5%	0.32747031	7.3134	1%	0.043386257
B	Waimanalo	0.75	277.2194	63%	5.730692824	48.3745	11%	97.3684	22%	2.012804267	9.14	2%	0.188942521	6.4972	1%	0.134310432
B	Waimanalo	4	358.459	62%	5.994367827	59.7993	10%	134.5223	23%	2.249563122	18.6	3%	0.31104043	7.5524	1%	0.126295793
B	Waimanalo	24	690.9548	49%	3.733203806	185.0836	13%	483.8217	34%	2.614071155	48.8	3%	0.263664636	11.0805	1%	0.059867541
C	Waimanalo	0.75	218.593	60%	5.15930392	42.3687	12%	88.191	24%	2.081513004	8.44	2%	0.199203657	5.1326	1%	0.121141314
C	Waimanalo	4	332.4958	56%	4.08863787	81.3219	14%	152.0639	26%	1.869900974	22.2	4%	0.272989195	6.946	1%	0.085413646
C	Waimanalo	24	579.5645	41%	2.521094142	229.8861	16%	504.9268	36%	2.196421619	74.4	5%	0.323638532	10.416	1%	0.045309395
A	East Honolulu	0.75	177.5544	56%	4.070481431	43.62	14%	82.0265	26%	1.880479138	7.82	2%	0.179275562	7.3703	2%	0.168966071
A	East Honolulu	4	305.6951	51%	3.335822418	91.6401	15%	167.5287	28%	1.828115639	22.4	4%	0.244434478	10.4745	2%	0.114300399
B	East Honolulu	0.75	168.3417	62%	4.394713553	38.3055	14%	50.6866	19%	1.323219903	6.64	2%	0.173343254	6.4942	2%	0.169537012
B	East Honolulu	4	256.2814	53%	3.692044169	69.4145	14%	125.8023	26%	1.812334599	19.1	4%	0.275158648	8.9286	2%	0.128627304
B	East Honolulu	24	439.6985	43%	2.171539354	202.4824	20%	310.9114	31%	1.535498394	46.6	5%	0.230143459	14.0625	1%	0.069450481
C	East Honolulu	0.75	177.5544	56%	4.031360048	44.0433	14%	84.472	27%	1.917930764	6.08	2%	0.138045968	6.5981	2%	0.149809392
C	East Honolulu	4	272.1943	54%	3.387034677	80.3636	16%	126.3775	25%	1.572571413	17.5	3%	0.21776028	6.9166	1%	0.086066329

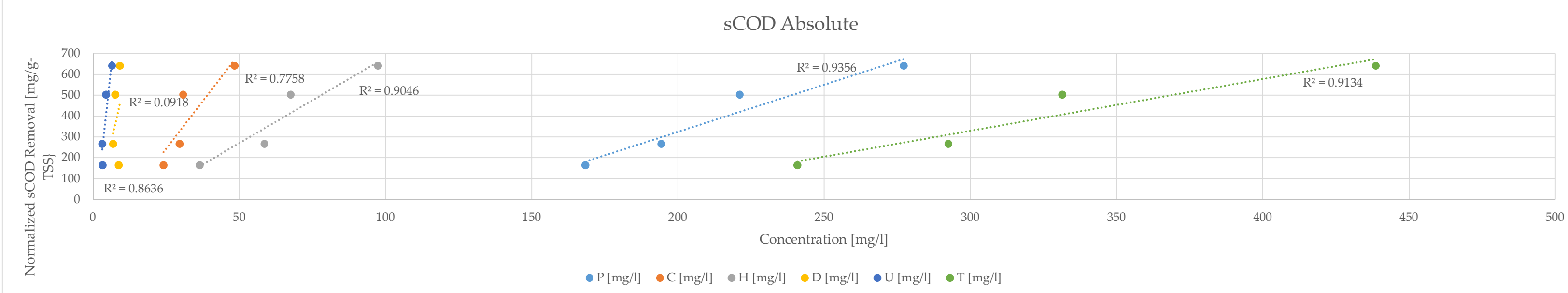


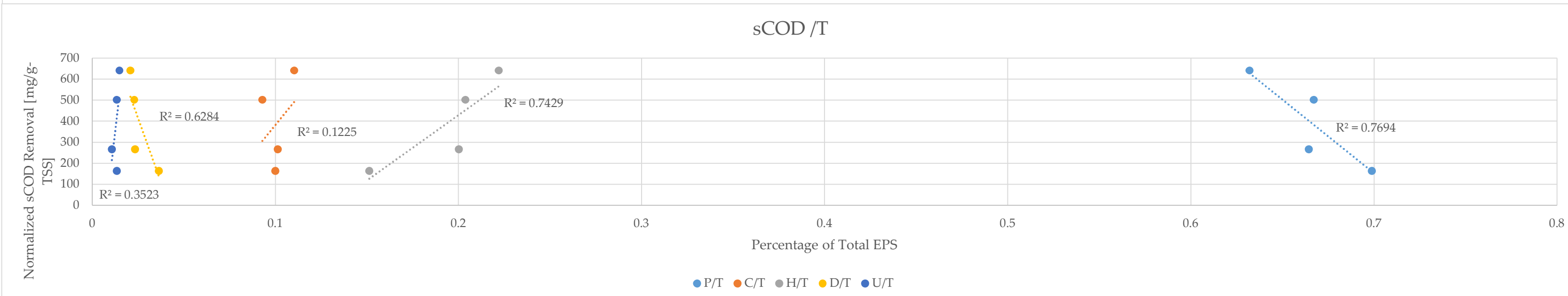


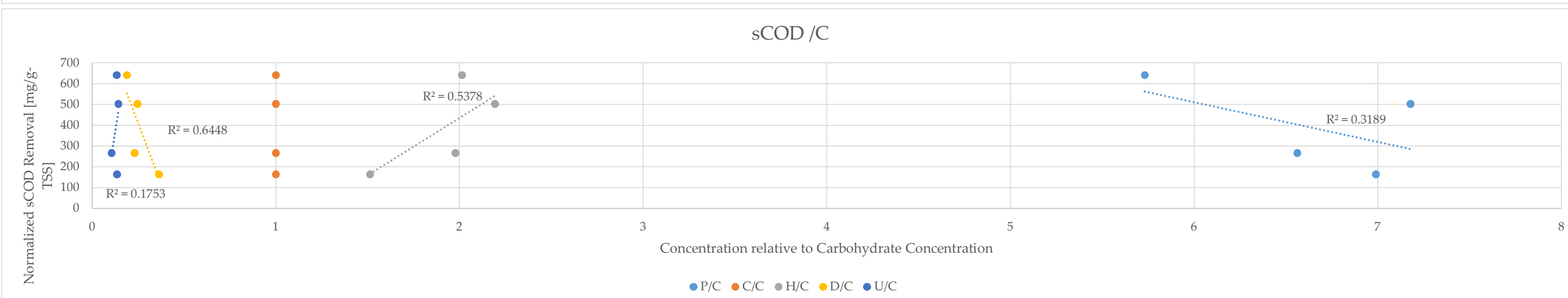


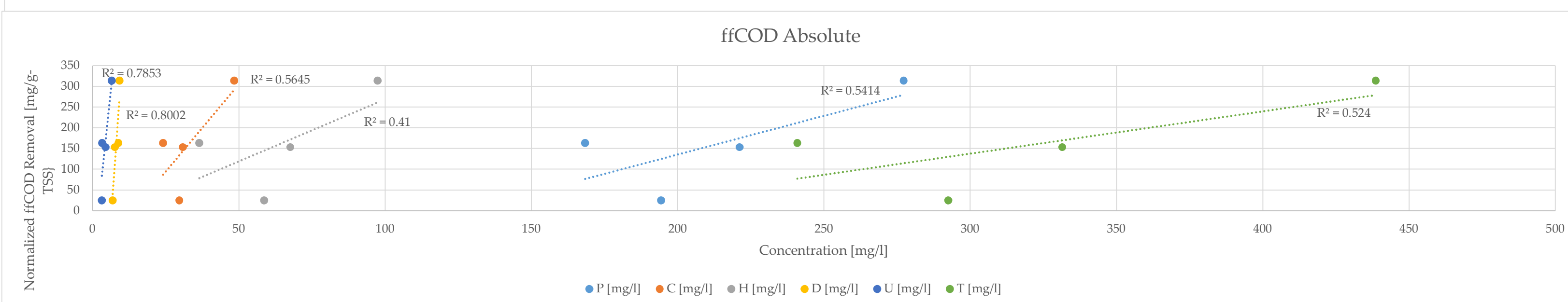


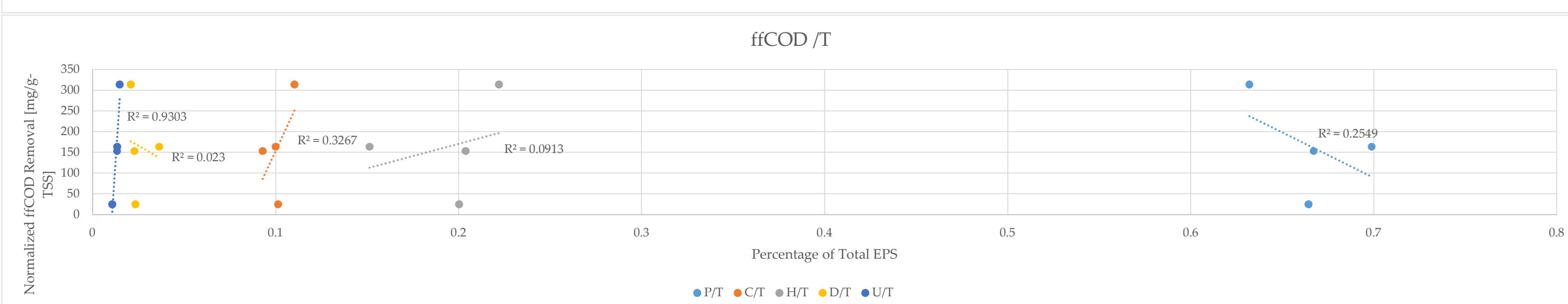
Normalized sCOD Re	Normalized ffCOD Re	Normalized kCOD Re	P [mg/l]	P/T	P/C	C [mg/l]	C/T	C/C	H [mg/l]	H/T	H/C	D [mg/l]	D/T	D/C	U [mg/l]	U/T	U/C	T [mg/l]
163.4636872	163.4636872	0	168.3417	0.698872	6.990122	24.0828	0.09998	1	36.4444	0.151299	1.513296	8.76	0.036367	0.363745	3.2475	0.013482	0.134847	240.8764
266.1279461	24.94949495	241.1784512	194.3049	0.664373	6.561539	29.6127	0.101253	1	58.567	0.200254	1.977766	6.84	0.023388	0.230982	3.139	0.010733	0.106002	292.4636
501.9402985	153.1343284	348.8059701	221.1055	0.667105	7.1784	30.8015	0.092932	1	67.54	0.203777	2.19275	7.58	0.02287	0.246092	4.4133	0.013316	0.143282	331.4403
641.25	313.6548913	327.5951087	277.2194	0.632056	5.730693	48.3745	0.110293	1	97.3684	0.221998	2.012804	9.14	0.020839	0.188943	6.4972	0.014814	0.13431	438.5995

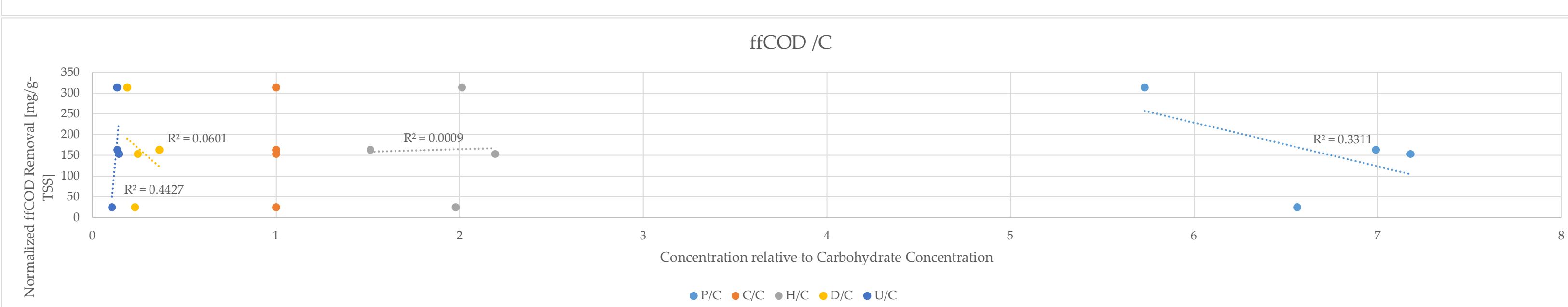


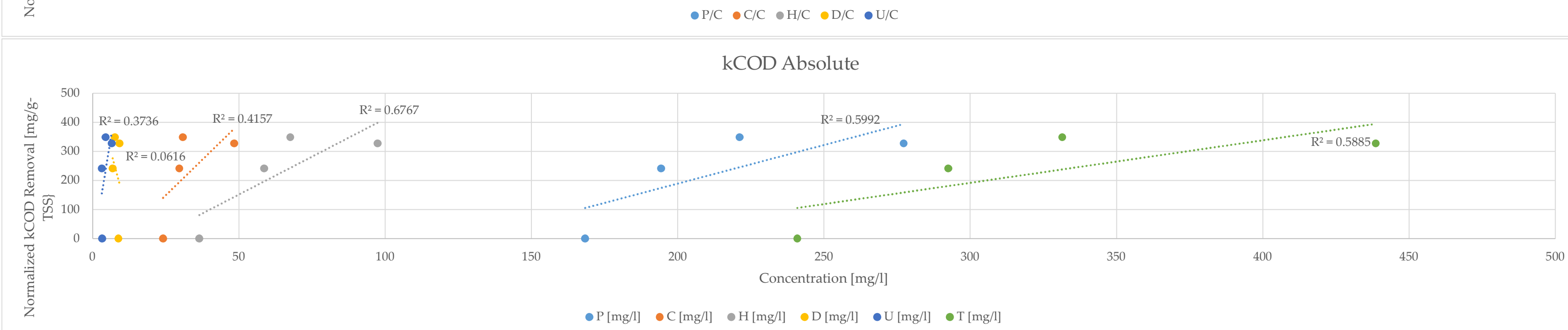


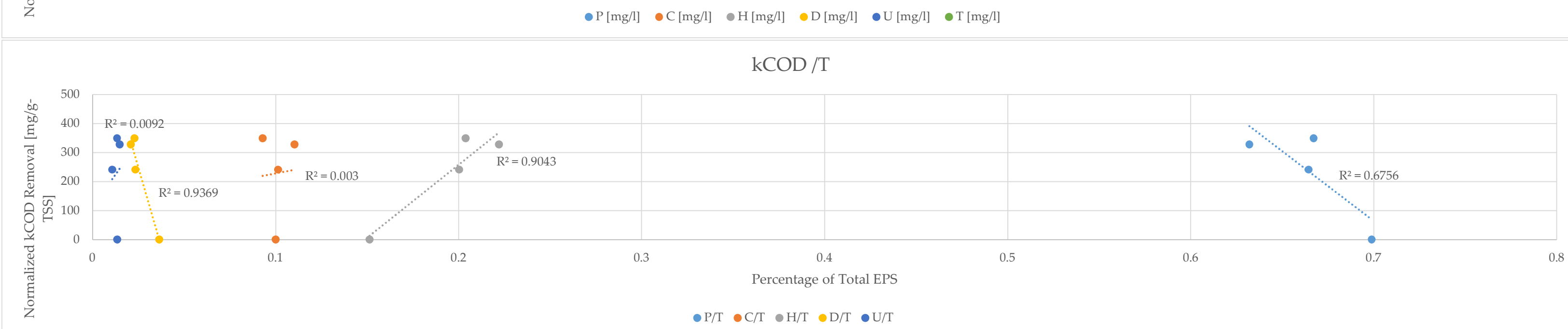


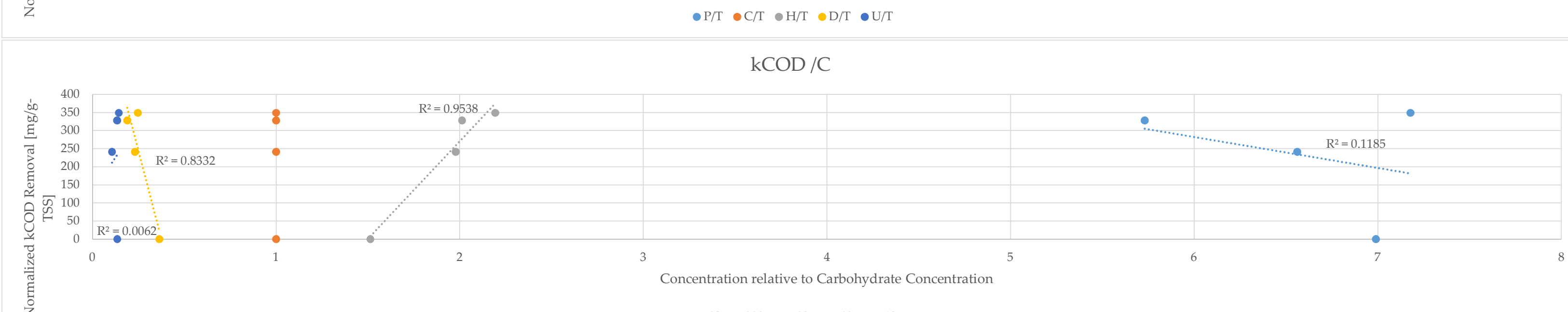












Photos

Photo 1: Biosorption Experiment Setup (Top View)

Photo 2: Biosorption Experiment Setup (Front View)

Photo 3: Pressure Vessel

Photo 4: Fine Screens

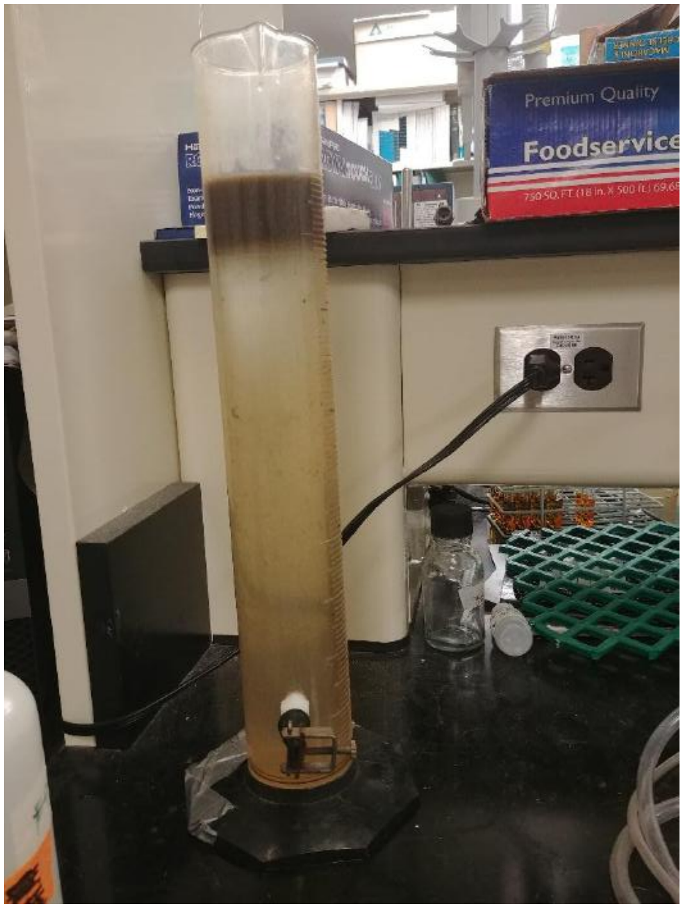


Photo 5: After DAF

Photo 6: Colorimetric Assay Tubes