Wisconsin Institute for Sustainable Technology
College of Natural Resources
University of Wisconsin - Stevens Point

FOOD SUPPLEMENT STUDY

Comparison of food supplements

Abstract

A follow up study to evaluate and updated formulation of Aquafix's SmartBOD compared to a popular glycerin based carbon source. The purpose of this study is to evaluate carbon sources and their ability to build biomass and their effect on effluent water quality.

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Contents

Executive Summary

The Wisconsin Institute for Sustainable Technology (WIST) is a department within the College of Natural Resources at the University of Wisconsin – Stevens Point Campus, located in Stevens Point, Wisconsin. The Wisconsin Institute for Sustainable Technology provides research, laboratory services and education for businesses and industry. Through our contract research, we work with companies such as AquaFix to bring new ideas and innovation to their respective industries.

Drawing of the success of the first round of experiments, AquaFix reached out to the Wisconsin Institute for Sustainable Technology (WIST) for additional trials. Initially AquaFix approached WIST to evaluate their product, SmartBOD and its effectiveness as a source of carbon for wastewater treatment facilities. AquaFix wanted an independent third party evaluation of SmartBOD. These sources of carbon are beneficial when wastewater plants have issues with low F:M ratios, need recovery from upset, or want to lower effluent nutrient levels.

After making updates in its formula, AquaFix wished to test its new product for its effectiveness as a source of carbon for wastewater treatment versus a glycerin based carbon source.

Experimental Design

We made use of two batch reactors from the previous study. Constructed out of 6" PVC pipe the reactors have a total volume of 7L and a working volume of 5L. The reactors have microcontrollers, controlling dissolved oxygen, pH and monitoring temperature. These microcontrollers also control feed pumps, wasting pumps, dilution pumps, and overhead mixing. WIST staff designed a custom, touchscreen interface to control and monitor the reactors. Shown in Figure 1 is a design schematic of the reactors.

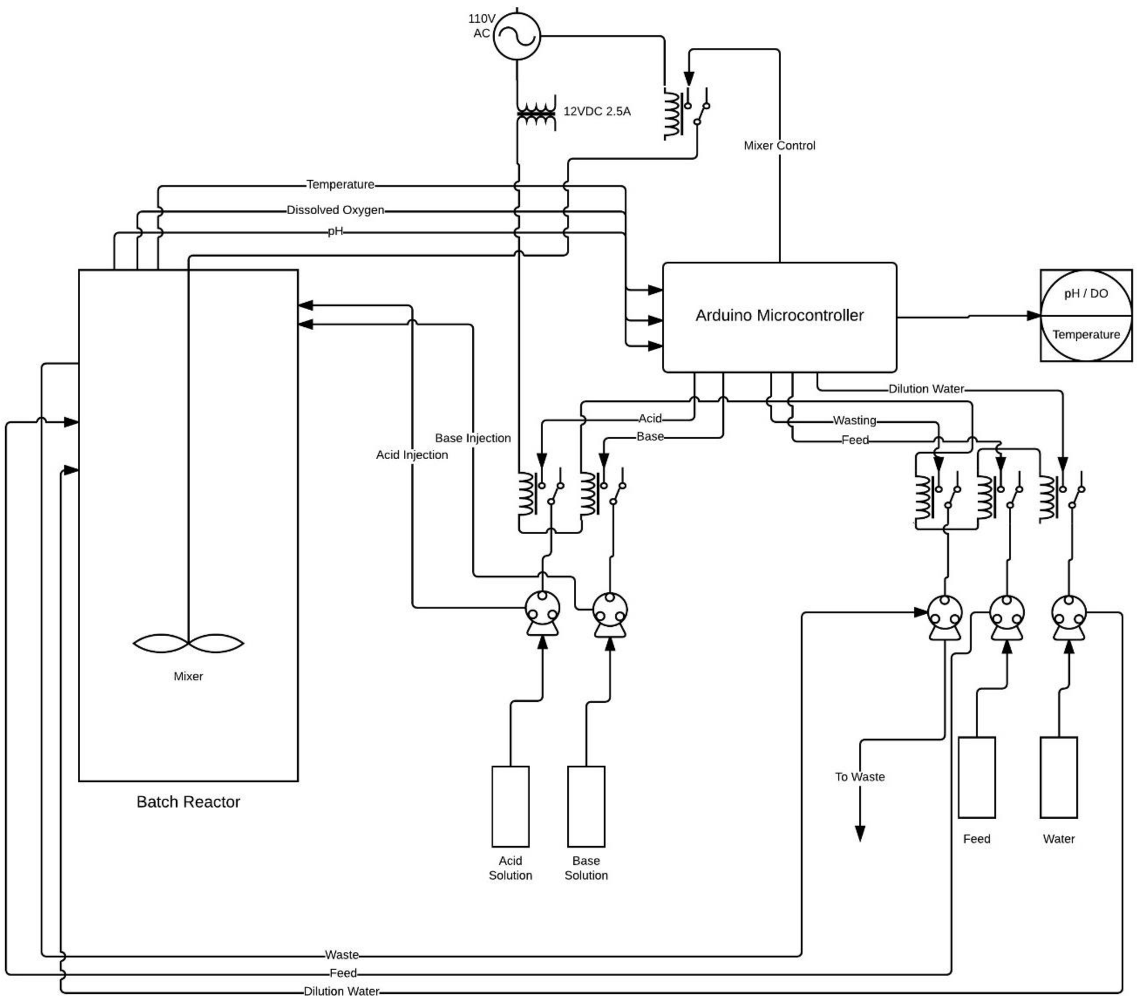

FIGURE 1: DESIGN SCHEMATIC FOR BATCH REACTORS

Experimental Conditions

Reactors have a source of carbon added to them as a food for the microorganisms responsible for the treatment of the wastewater. The experiment sought to test the effectiveness of AquaFix's SmartBOD to a glycerin based carbon source.

Reactors have controls for monitoring pH, dissolved oxygen and temperature. The reactor control interface allowed for setting control limits for pH and dissolved oxygen. The use of acid/base addition and an air pump allowed the reactors control interface to keep these values within limit. The reactors have no control for temperature, only monitoring. A SD card interface logs all pH, dissolved oxygen, and temperature readings.

We set the conditions for the experiment after discussions with AquaFix. Table 1 lists the experimental conditions.

TABLE 1: EXPERIMENTAL CONDITIONS IN BATCH REACTORS

Parameter	Setpoint
BOD of influent	250 mg BOD / L * day^{-1}
pH	7.30 – 7.50
Dissolved oxygen	2.8 mg/L
Temperature	Not controlled
Feed & decant cycles per day	3
Volume decanted per day	1L
Feedstock added per day	100mL
Dilution water added per day	900mL
MLSS wasted	Varies, controlled at 1500 mg/L

To control pH we used a 5% solution of sodium carbonate, and a 0.1M hydrochloric acid solution. The design of the reactor requires that the carbon source be a liquid. SmartBOD is in a powdered form and required suspension in water. Continual mixing of this slurry occurred from an overhead mixer. The glycerin based carbon source is already in a liquid form and only required appropriate diluting to meet the BOD requirements as listed in Table 1. Slurries are stored at 4°C to help inhibit microbial growth.

Reactors complete three cycles daily. Each cycle lasts eight hours. Figure 2 below details cycle steps.

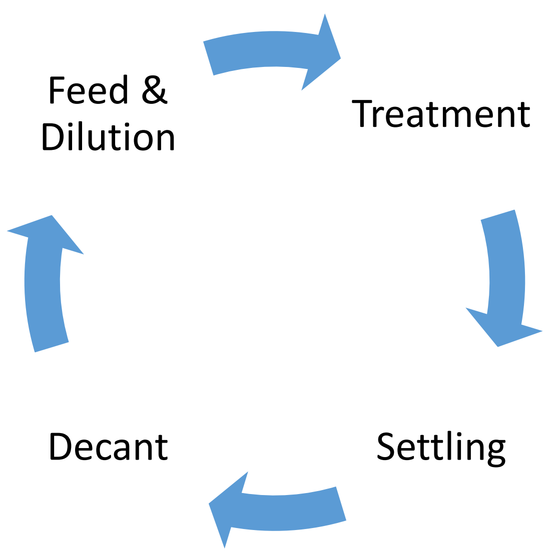

FIGURE 2: REACTOR CYCLE

Test Methods

Testing occurred for the following analytes; ammonium, soluble reactive phosphorus, chemical oxygen demand, mixed liquor suspended solids, effluent suspended solids, and sludge volume index. Table 2 lists the standard test method used.

TABLE 2: LIST OF STANDARD METHODS

Test	Method
Ammonium (NH_3-N)	SM4500 NH_3H
Soluble reactive phosphorus (PO_4^{3-})	SM4500 PG
Chemical oxygen demand	SM 5220 D
Mixed liquor suspended solids	SM2540 D
Effluent suspended solids	SM2540 D
Sludge volume index	SM2710 D

WIST staff completed chemical oxygen demand, mixed liquor suspended solids, effluent suspended solids and sludge volume index in WIST laboratories. Ammonium and soluble reactive phosphorus are subcontracted to the Water and Environmental Analysis Lab located on the University of Wisconsin – Stevens Point campus.

Results & Discussion

Ammonium and Soluble Reactive Phosphorus

Ammonium and soluble reactive phosphorus are two nutrients measured by wastewater treatment plants. Analysis for these nutrients occurred on reactor effluents. The glycerin based carbon source reactor presented with low, but detectable levels of ammonium, with none present (except for initial) in the SmartBOD reactor (Table 3, Figure 3).

Phosphorus, measured as SRP presented in both reactors (Table 4, Figure 4). Concentrations in both reactors increased during the study. The reactor with the glycerin based carbon source had the highest final concentration of SRP.

TABLE 3: AMMONIUM CONCENTRATIONS IN REACTOR EFFLUENT

	SmartBOD	Glycerin based carbon source
	mg/L NH_3-N	
3/2/2017	0.05	0.05
3/6/2017	0.00	0.00
3/13/2017	0.00	0.06
3/20/2017	0.00	0.04
3/27/2017	0.00	0.05
4/3/2017	0.00	0.10

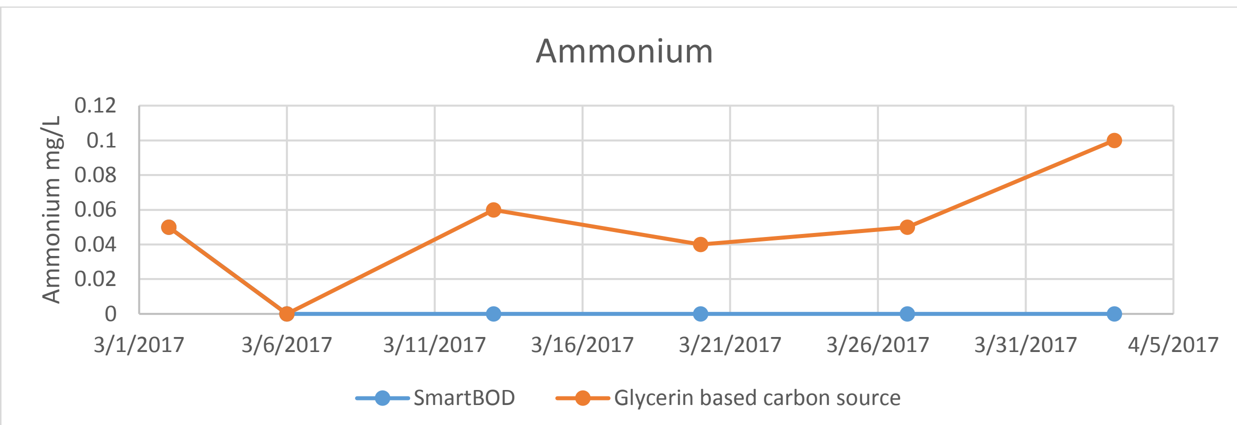

FIGURE 3: AMMONIUM CONCENTRATION IN REACTOR EFFLUENT

TABLE 4: SRP CONCENTRATIONS IN REACTOR EFFLUENT

	SmartBOD	Glycerin based carbon source
	mg/L PO_4^{3-}	
3/2/2017	0.051	0.051
3/6/2017	0.102	0.054
3/13/2017	0.204	0.158
3/20/2017	0.259	0.214
3/27/2017	0.291	0.313
4/3/2017	0.241	0.346

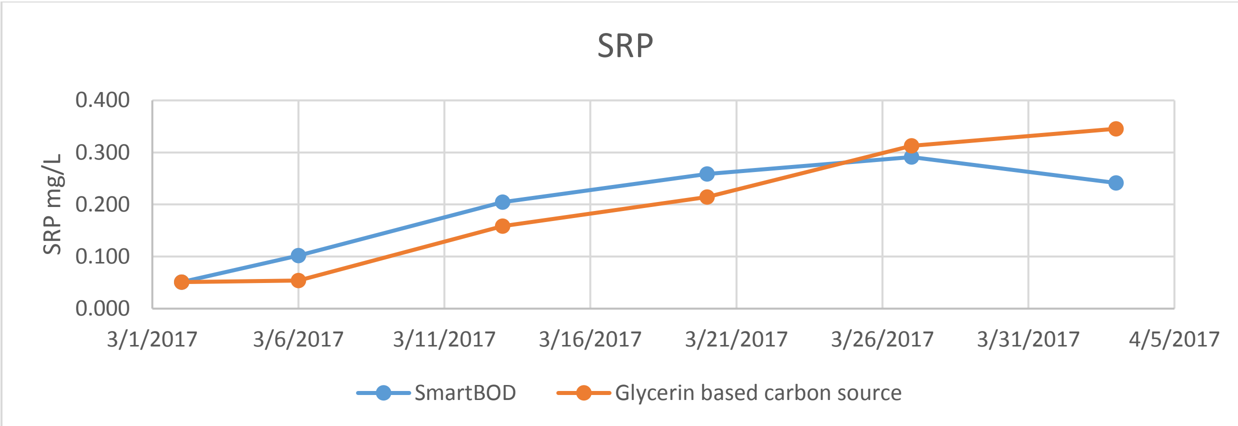

FIGURE 4: SRP CONCENTRATIONS IN REACTOR EFFLUENT

Chemical Oxygen Demand

Chemical oxygen demand (COD) in reactor effluent is an indicator to the effectiveness of the wastewater treatment process. WIST staff tested COD in reactor effluent, with results listed in Table 4 and Figure 5. Levels of COD in reactor effluents were similar at the start of the experiment. However, levels of COD in the reactor using the glycerin based carbon source increased during the second half of the experiment. This increase would indicate that the ability of the MLSS ability to treat the wastewater is decreasing. Levels of COD in effluent from reactor using SmartBOD remained constant. This stable, continual removal of COD indicates that the MLSS is effective in its treatment.

TABLE 5: VALUES FOR CHEMICAL OXYGEN DEMAND IN REACTOR EFFLUENT

	SmartBOD	**Glycerin based carbon source**
	mg/L COD	
3/2/2017	10	10
3/6/2017	35	45
3/13/2017	55	25
3/20/2017	35	75
3/27/2017	40	90
4/3/2017	40	155

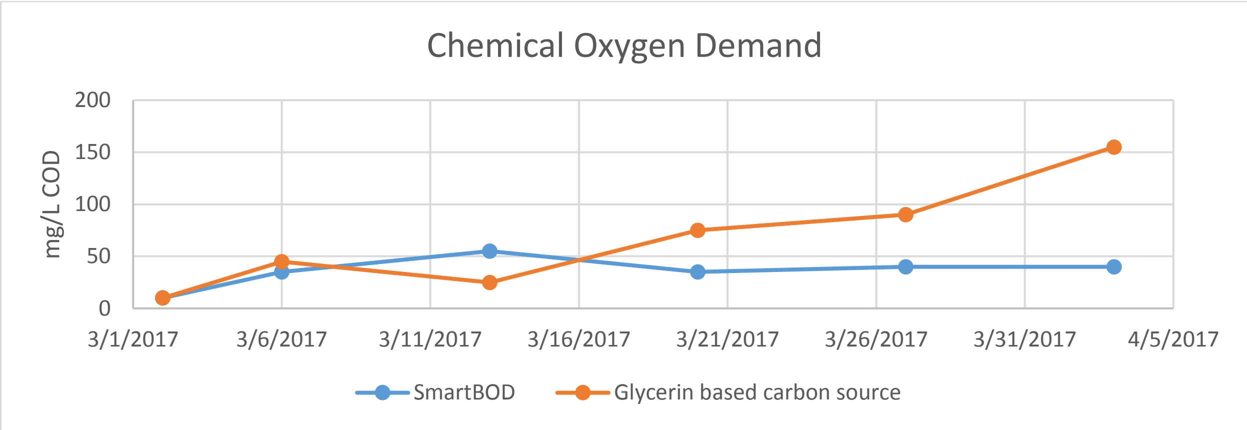

FIGURE 5: CHEMICAL OXYGEN DEMAND IN REACTOR EFFLUENT

Sludge Volume Index

Sludge volume index (SVI) is an additional metric used to quantify the health of MLSS. SVI is the volume of solids occupied after a 30-minute settling period. This test describes the ability of the MLSS to settle and compact. SVI values tend to differ from treatment process to treatment process. There are general guidelines published and are reported in Table 6.

TABLE 6: GUIDELINES FOR SVI

SVI	Sludge Characteristics
< 80 mL/g	Dense with rapid settling. Old and potentially over oxidized
100 to 200 mL/g	Good quality effluent. Medium settling, irregular flocs
> 250 mL/g	Slow settling, poor floc formation

The initial sludge volume index on the wastewater had a value of 235 mL/g, slightly elevated above the optimal range according to the guidelines. We do not believe that this is a cause for concern as it is only slightly above the high range of 200 mL/g for optimal sludge settling. The SVI for the SmartBOD reactor remained steady around 200 mL/g. WIST staff observed good floc formation during the test. SVI for the glycerin based carbon source trended downward during the experiment. The flocs became dense and compacted at the end of the experiment.

TABLE 7: MIXED LIQUOR SLUDGE VOLUME INDEX

	SmartBOD	Glycerin based carbon source
	SVI mL/g	
3/2/2017	235	235
3/7/2017	165	155
3/10/2017	210	160
3/14/2017	195	145
3/21/2017	185	130
3/28/2017	205	120
4/3/2017	170	75

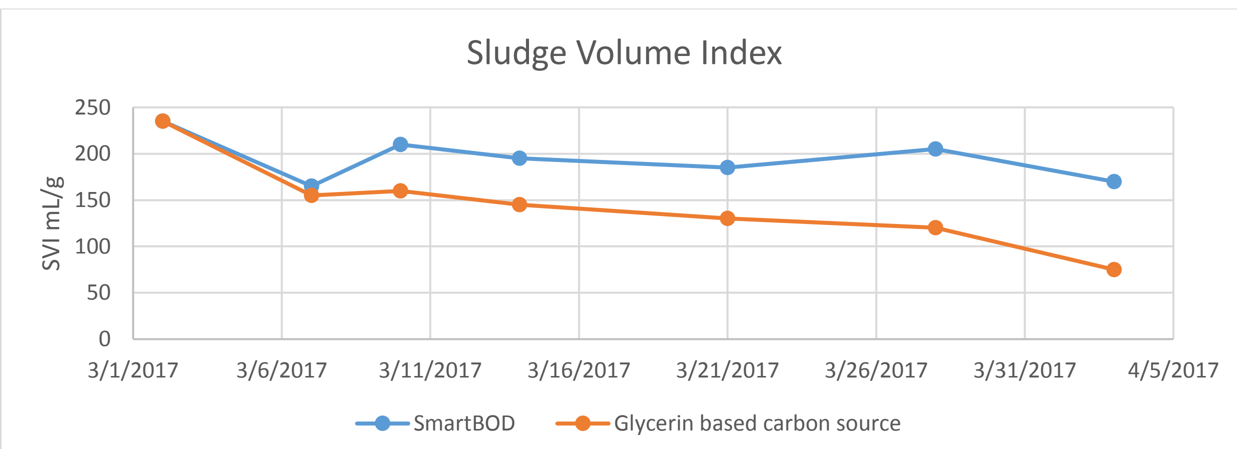

FIGURE 6: MIXED LIQUOR SLUDGE VOLUME INDEX

Suspended Solids

Mixed liquor suspended solids is another test to aid in quantifying the health of wastewater sludge. Testing for MLSS occurred on a regular basis. The test for MLSS is done for two reasons; first it allows WIST staff to know how much of the MLSS to waste, and secondly it gives a picture of the health of the sludge over time. Wastewater operators keep MLSS at a constant level. This requires regular wasting, or removal, of a portion of the sludge.

WIST staff took measurements of MLSS to determine wasting amounts. The target value for MLSS during this experiment was 1500 mg/L. MLSS results, listed in Table 8 were pre-wasting values. These values allowed WIST staff to calculate how much of the sludge to remove from the reactors.

Continual MLSS growth occurred from the reactor fed with SmartBOD. This indicates that the microorganisms present have enough food and nutrients to multiply. Continual removal of sludge also lowers the age of it. The reactor fed with the glycerin based carbon source did not have the amount of MLSS growth as observed in the SmartBOD reactor. The reactor with the glycerin based carbon source had a gradual decrease in MLSS during the study.

TABLE 8: MLSS BEFORE WASTING

	SmartBOD	Glycerin based carbon source
	Reactor MLSS mg/L	
3/2/2017	1500	1500
3/6/2017	1685	1610
3/9/2017	1595	1575
3/10/2017	1550	1450
3/13/2017	1710	1490
3/15/2017	1650	1490
3/17/2017	1650	1405
3/21/2017	1800	1325
3/24/2017	1877	1420
3/25/2017	1490	1350
3/28/2017	1595	1275
3/30/2017	1705	1135
4/3/2017	1595	1190

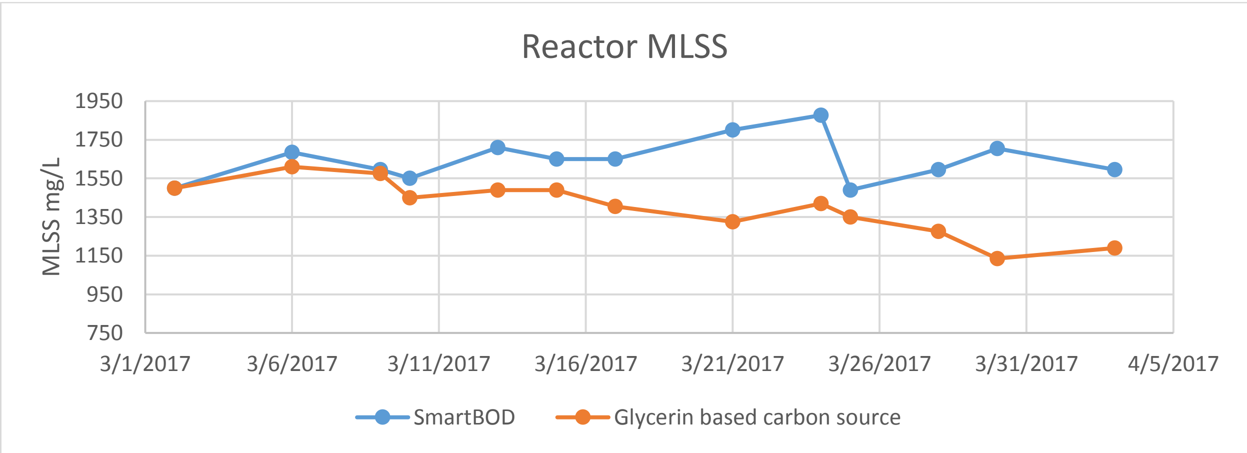

FIGURE 7: MLSS BEFORE WASTING

We also tested for the suspended solid (SS) values in the reactor effluents. See Table 9 and Figure 8 for reported values. Reactor effluent suspended solids appeared to reach an equilibrium early in the study.

TABLE 9: EFFLUENT SUSPENDED SOLIDS

	SmartBOD	Glycerin based carbon source
	Effluent SS mL/g	
3/7/2017	80	45
3/10/2017	65	50
3/14/2017	65	75
3/21/2017	60	70
3/28/2017	50	70
4/3/2017	65	80

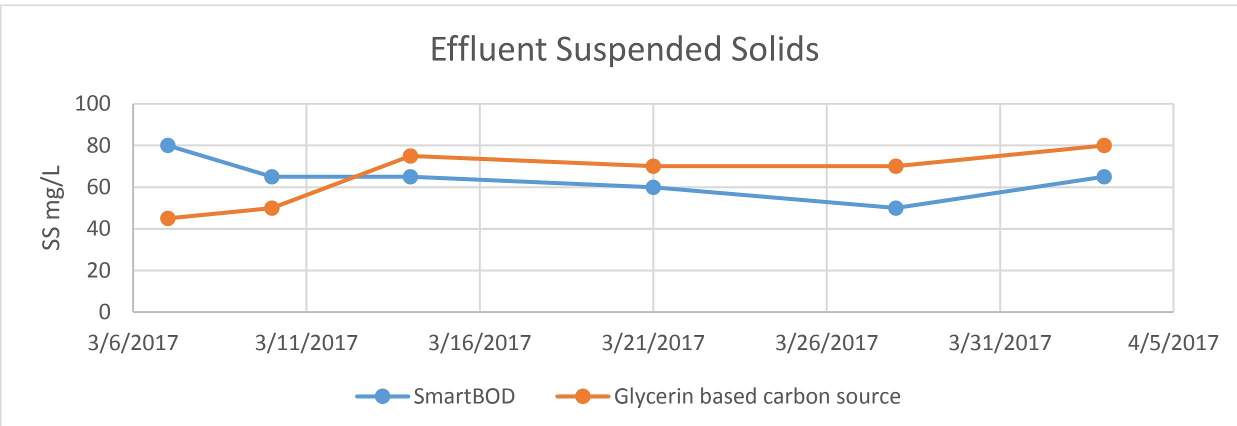

FIGURE 8: EFFLUENT SUSPENDED SOLIDS

Conclusion

Addition of SmartBOD as a carbon source outperformed the glycerin based carbon source in terms of COD removal, settling, floc formation, and ammonium removal. There was no clear advantage to phosphorus removal. The evidence from this study supports that SmartBOD is an efficient source of carbon for wastewater treatment plants as compared to the glycerin based carbon source.