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Bioaugmentation Evaluation for Improving Water Quality of American Fork Harbor

Himanshu Ramesh Lamba[1], Macaylah Mendenhall, Juan Carlos Verardo[1], Georgia Crockett

[1]BiOWiSH Technologies, 2717 Erie Ave, Cincinnati OH, 45208

Abstract: ***Bioaugmentation technology was evaluated to improve the water quality of American Fork Harbor. The technology used for this study contains a novel consortium of metabolically cooperative microorganisms with endogenous and exogenous enzymes, and small molecule co-factors which support both biocatalytic and metabolic activity and are composed of all-natural materials and non-genetically modified. The study focused on improving the water quality of one of the harbors at Lake Utah over a period of 7 weeks. It was concluded that 7 weeks of Bioaugmentation showed measurable improvement in key water quality indicators. The data generated during this study indicates that Bioaugmentation Technology can help to improve the water quality at American Fork Harbor during summer months, leading to an increased microbial biodiversity in the water column***

Keywords: Bioaugmentation, Utah, American Fork Harbor, *Water Quality, Bioremediation*

1. Introduction

Utah Lake is a huge and complex lake in Utah Valley, taking up about half of the valley's space. It is only about 9 feet deep and spreads across 150 square miles when it is full. As per Lavere B. Meritt who is a professor, researcher, environmental engineer and consultant, people have different opinions about the lake, some see it as a beautiful treasure, while others think it's just a useless swampy pond.[1]

Evaporation in the Utah Lake accounts for 42% of the outflow which leaves the lake slightly saline. Utah Lake's watershed drains 3,846 square miles (9,960 km^2) over mostly mountainous terrain. Two major tributaries account for nearly 60% of inflow by streams or rivers into Utah Lake. The Provo River accounts for 36% of the inflow, and the Spanish Fork River accounts for 24%.[2]

Other Major tributaries are American Fork River, Mill Race Creek, Hobble Creek, Currant Creek, and numerous irrigations returns.[3]

This study focuses on evaluating all-natural, environmentally safe, and eco-friendly bioaugmentation technology to improve the water quality of American Fork Harbor.

The study was started on Sep 15th, 2020 and was evaluated for a duration of 7 weeks.

2. Bioaugmentation Technology

The bioaugmentation technology used for this study is a proprietary composite biocatalyst that enhances a broad range of hydrolytic, oxidative, and reductive biochemical reactions. It contains a novel consortium of metabolically cooperative microorganisms with endogenous and exogenous enzymes, and small molecule co-factors which support both biocatalytic and metabolic activity. They are composed of all-natural materials and non-genetically modified.

Figure 1: Satellite Image of American Fork Harbor[4]

3. Dosing

For dosing, the American fork harbor was arbitrarily divided into 6 sections and Bioaugmentation technology was dissolved in water and sprayed on the surface of each section once a week.

4. Sampling

Composite sampling was chosen to minimize the number of samples analyzed while guaranteeing adequate representation of the body of water. The harbor was divided into two sections – AFH1 and AFH2 and 6 sampling points were identified for each section.

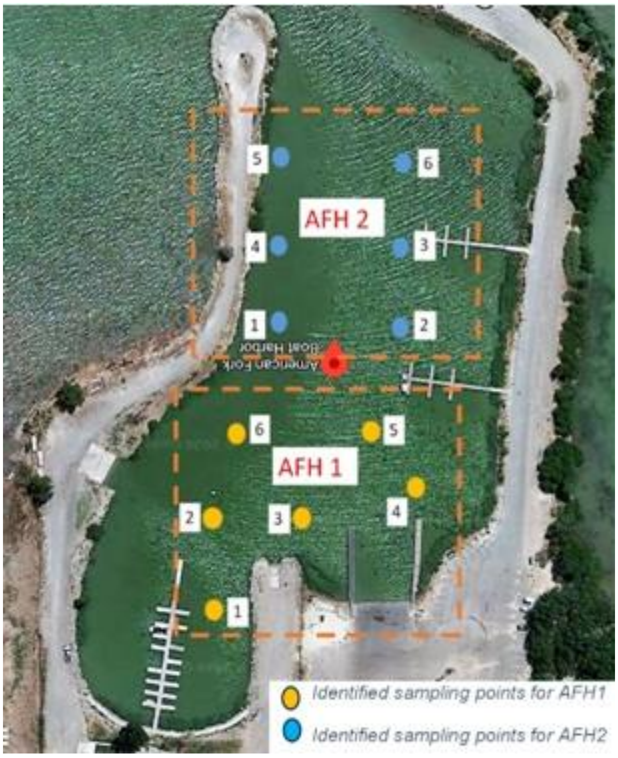

Figure 2: Identified sampling points for AFH1 and AFH2[4]

From each sampling point, water and sludge samples were collected and combined in a 5-gal bucket. Separate buckets were used to collect sludge and water samples from AFH1 and AFH2. Water samples and sludge samples from each bucket were then drawn, labelled with section name and date of sampling. The samples were preserved with ice and delivered to the AWAL lab the same day for testing.

5. Results:

Ammonia N concentration is widely used as an indicator of total nitrogenous matter in surface waters. Along with TP, it is used as the most basic indicators for eutrophication potential.[5] The ammonia N levels in American Fork Harbor were very low before starting the bioaugmentation exercise and remained < 0.2mg/l (on average) throughout.

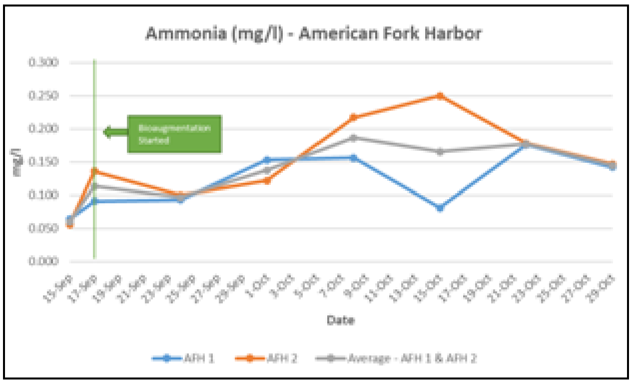

Figure 3: Ammonia N (mg/l) graph

Table 1: AWAL Testing methods, preservation and holding time

Parameter	Testing method	Preservation	EPA holding time
BOD	SM 5210B	1L plastic, on ice, 0-6˚C	48 hour holding time
COD	HACH 8000	250 mL plastic preserved with H2SO4, on ice, 0-6˚C	28 day holding time
NH3	EPA 350.1	(includes distillation) same bottle as COD	28 day holding time
NO2	EPA 353.2	1L plastic, on ice, 0-6˚C	48 hour holding time
NO3	EPA 353.2	1L plastic, on ice, 0-6˚C	48 hour holding time
TKN	EPA 351.2	250 mL plastic preserved with H2SO4, on ice, 0-6˚C	48 hour holding time
Organic N	Organic N = TKN – NH3		
Total P	SM 4500(P)B/F	same bottle as TKN	28 day holding time
TDS	SM 2540 C	same bottle as NO2, NO3	7 day holding time
TSS	SM 2540D	same bottle as NO2, NO3	7 day holding time
% Organic in Sludge	SM 2540E	2oz jar, on ice 0-6 ˚C	7 day holding time

Nitrite and Nitrate concentrations are used as indicators of nitrification in water bodies. Nitrite, the partially oxidized anion, is unstable and is usually considered a qualitative indicator that biologically mediated nitrification is occurring.[6]

Both Nitrite and Nitrate levels were non-detectable before starting the bioaugmentation protocol. However, we saw Nitrate concentrations > 0.3 mg/l for most of the September October period. This could be seen as an indicator that overall nitrification has been boosted due to the bioaugmentation of the water body. This increase in Nitrite/Nitrate did not result in any changes in Total Nitrogen – pointing at no effect in overall denitrification.
Total Nitrogen levels remained low and stable throughout the 44-day implementation.

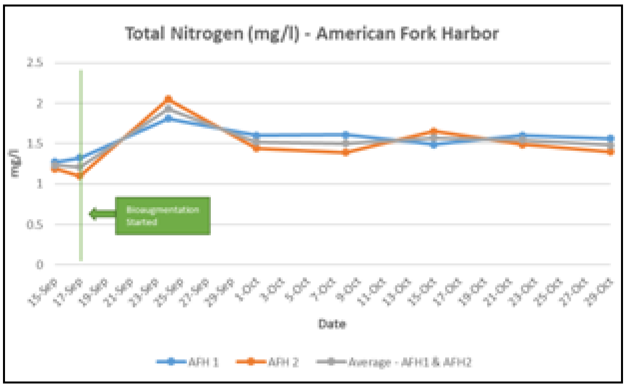

Figure 4: Total Nitrogen (mg/l) Graph

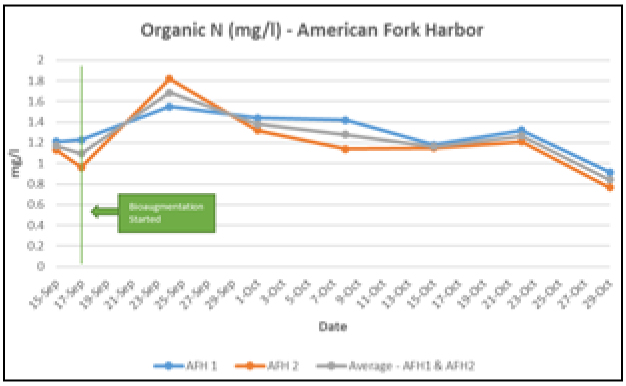

Figure 5: Organic N (mg/l) Graph

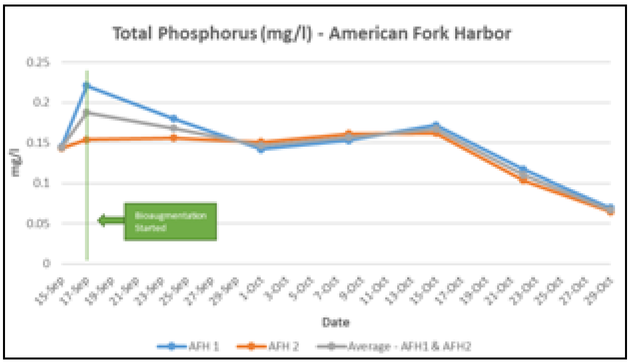

Figure 6: Total Phosphorus (mg/l) Graph

The total phosphorus levels showed a diminishing trend during the entire trial duration. A 52% reduction was observed in the total phosphorus levels in AFH1 whereas 55% reduction was observed in AFH2 over a period of 44 days. This is most significant since TP concentration is one of the main indicators of eutrophication potential in surface waters.

Biological available Carbon remained low < 15 mg/l on average throughout (except for a single sample > 35 mg/l mid-October). These BOD levels are consistent with a visually clean large body of water such as Utah lake.

COD (chemical oxygen demand) plotted below, shows a similar story of low total carbon for the water body.

As expected, organic fraction for the sludge was low < 5% and, mostly, consisting of recalcitrant carbon forms.

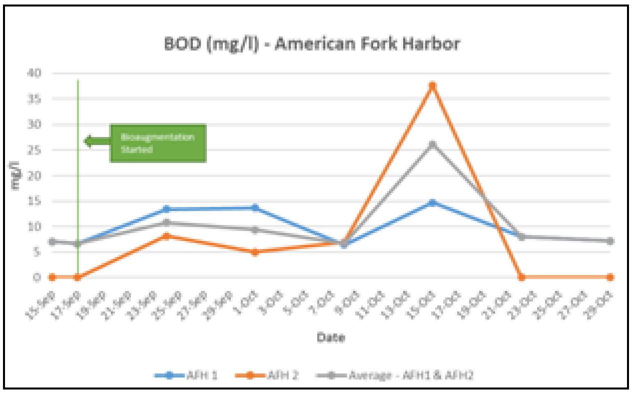

Figure 7: BOD (mg/l) Graph

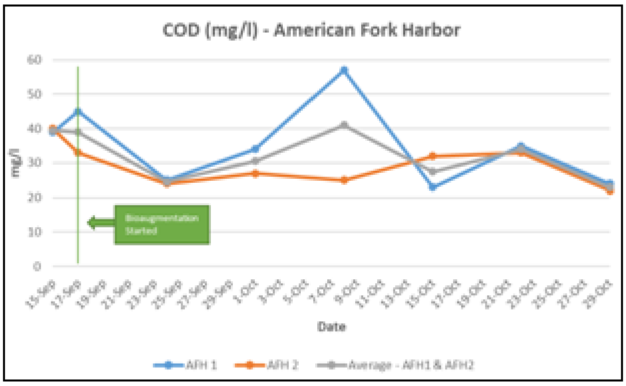

Figure 8: COD (mg/l) Graph

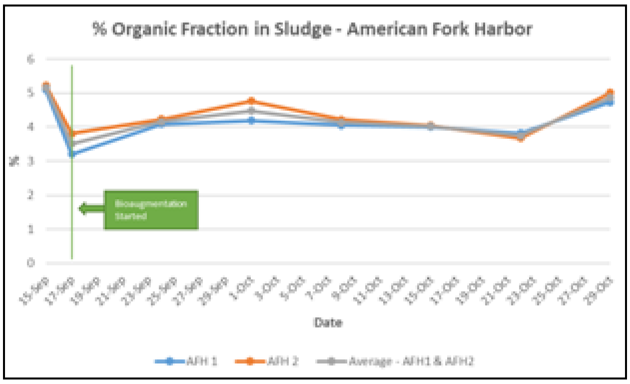

Figure 9: % Organic Fraction in Sludge (mg/l) Graph

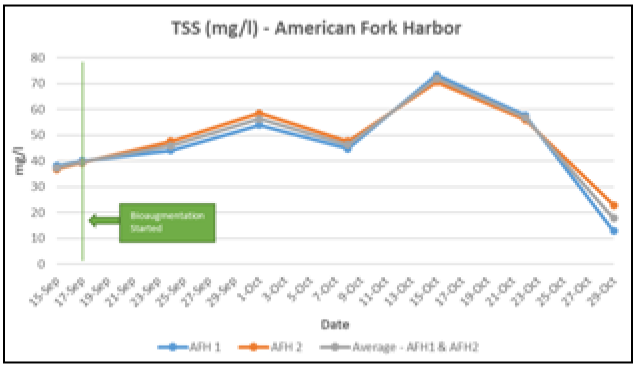

Figure 10: TSS (mg/l) Graph

The Secchi disk (or Secchi disc), as created in 1865 by Angelo Secchi, is a plain white, circular disk 30 cm (12 in) in diameter used to measure water transparency or turbidity in bodies of water. The disc is mounted on a pole or line and lowered slowly down in the water. The depth at which the disk is no longer visible is taken as a measure of the transparency of the water. This measure is known as the Secchi depth and is related to water turbidity.[7]

Table 2: AWAL Testing methods, preservation and holding time

Secchi Disk Readings	Before trial (Sep 15th)	After Trial (Oct 29th)	Remarks
AFH 1	8.70 inch	13.9 inch	60 % improvement
AFH 2	9.32 inch	13.0 inch	39 % improvement

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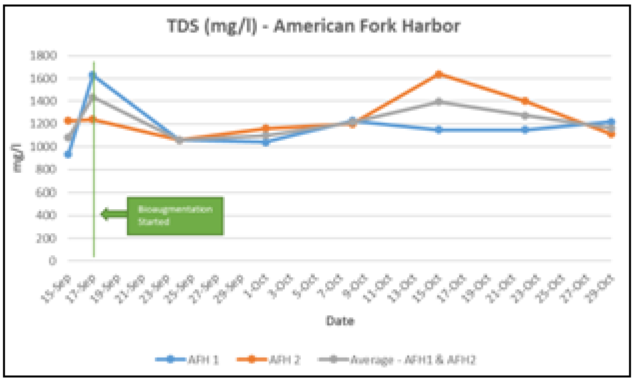

Figure 11: TDS (mg/l) Graph

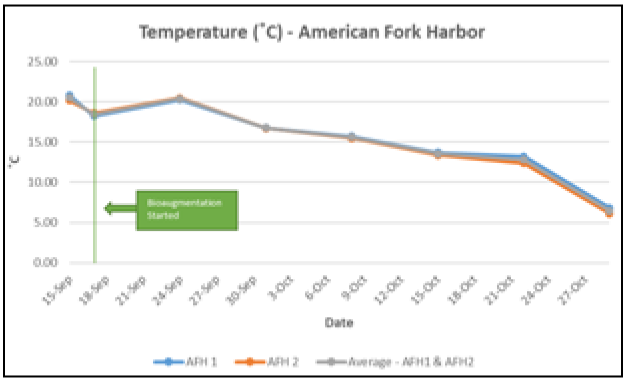

Figure 12: Temperature (°C) Graph

Water temperature was the single most important factor in the 44-day period. Unfortunately, we were unable to secure the needed permits to start the implementation in July. Starting mid-September, meant having over 20 days with mean temperatures < 15.5ºC (60ºF), the heterotrophic *Bacillus sp* formulated into the Bioaugmentation Technology see a measurable drop in metabolic speeds < 15ºC with almost no activity < 8ºC.

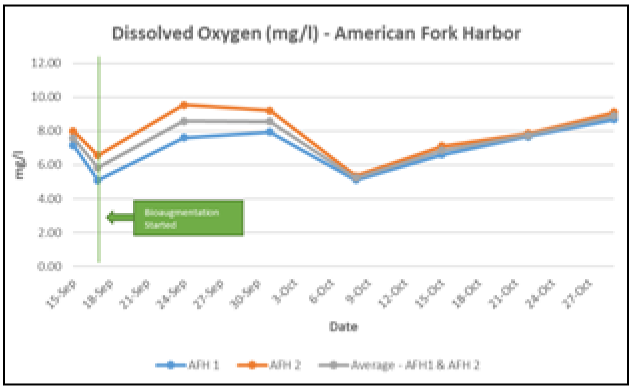

Figure 13: Dissolved Oxygen (mg/l) Graph

Repeating this study on a longer period of time while water temperatures are > 20ºC (July through September) would provide a more relevant data gathering opportunity.

6. Conclusion

The bioremediation of American Fork Harbor performed using Bioaugmentation technology for a period of 7 weeks showed measurable improvement in key water quality indicators. The data generated during this trial indicates that Bioaugmentation can help to improve the water quality at American Fork Harbor during summer months, leading to an increased microbial biodiversity in the water column.

Water samples collected before the initiation of bioremediation trial, during the trial period and after the final dosing were analyzed for various parameters. The conclusion of the study are as follows:

Table 3: Results before and after Bioaugmentation

Parameter	Before dosing (Sep 15th, 2020)	After dosing (Oct 29th, 2020)	Observations	Remarks
COD (mg/l)	39.5	23	Reduced by 42%	Improved
TKN (mg/l)	1.23	0.99	Reduced by 19%	Improved
Organic N (mg/l)	1.17	0.84	Reduced by 28%	Improved
TSS (mg/l)	37.4	17.80	Reduced by 52%	Improved
Total P (mg/l)	0.144	0.07	Reduced by 53%	Improved
Organic fraction in sludge (%)	5.16	4.87	Reduced by 6%	Improved

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