Craft Beverage Wastewater Vermifiltration Study, 2024

Lakeshore Environmental, Inc – Grand Haven, MI

Abstract

A pilot test was conducted to assess the wastewater treatment efficacy of vermifiltration on craft beverage processing wastewater. Vermifiltration utilizes the symbiotic relationship between worms and microorganisms in soils to treat wastewater. Applicability in the Michigan Craft Beverage industry has not been documented. Raised beds were used to simulate treatment of Michigan winery wastewater via land application through vermifiltration, bed containing worms. A control bed with no worms was also used for comparison. Results indicate that land application does provide wastewater treatment but additional work should be completed to determine whether Vermifiltration is feasible full scale.

Original Goals and Objectives of the Project

Vermifiltration is a new approach to sustainable wastewater treatment. The process utilizes the symbiotic relationship between worms and microorganisms to treat wastewater. The practice is a desirable, sustainable wastewater management option for implementation in Michigan craft beverage industry. This pilot study utilized wastewater from a winery in Southeast Michigan and simulated wastewater treatment to provide data on the efficacy of vermifiltration for winery wastewater treatment in Michigan. With the data collected, it is desirable to expand the implementation of vermifiltration as a sustainable wastewater best management practice in Michigan. Michigan specific data for the efficacy of vermifiltration will continue to encourage the development and implementation of sustainable wastewater treatment practices and systems. This data may also provide information for other Michigan craft beverage industries and improve the overall sustainability of the industry.

Period of time research was conducted

The pilot test was conducted across three seasons representative of seasonality in winery wastewater, specifically: November 2023, February 2024, and July 2024. With climate variability across North America, analysis of treatment efficacy specific to Michigan's production seasons is necessary.

Work accomplished during period, including methods

LEI utilized worms and subbase provided by Vermicompost to create the two pilot test beds (one control, one treatment). Each bed contained a layer of pea gravel, 2.5 gallons of mulch and was topped with approximately 9 gallons of woodchips. There were 3 lbs. of worms within the mulch in the treatment bed. The beds were set-up on November 13, 2023 and the first pilot test round was conducted on November 14, 2023. The other two pilot test rounds were conducted on February 27, 2024 and July 10, 2024. Each test was able to maintain a relatively consistent test method while variable weather, wastewater quality, and age or time of worms within the beds

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varied. The consistent methodology is outlined below, this method was used with both the treatment and control beds simultaneously.

1) Wastewater from the partner winery was collected into 5-gallon buckets, field readings were collected, and a raw, or initial, sample was collected ("Raw").
2) Approximately 10 gallons of the wastewater were applied to the beds via a standard watering can, to mimic irrigation and provide even distribution of the wastewater throughout the bed.
3) Wastewater that infiltrated through the beds was collected in pans below the bed. This water was used for sampling, field readings and/or reapplication via the method outlined in the step above.
4) Specifically, samples were collected following the first application or soak ("Soak 1") and following the third round of application of the wastewater to the beds ("Soak 3").

Samples for Raw, Soak 1, and Soak 3 for both treatment and control were stored on ice and transported to a certified lab for analysis of the following parameters:

- Phosphorus, Total
- Sodium, Total
- Biochemical Oxygen Demand (BOD)
- Chloride
- Nitrogen (Nitrate)
- Nitrogen (Nitrite)
- Ammonia as Nitrogen
- TIN (Calculated)

Additionally, the following analysis was completed utilizing available and properly calibrated field meters by LEI personnel throughout each pilot test round.

- Temperature (°C)
- pH (s.u.)
- Conductivity (µS/cm)
- Dissolved Oxygen (DO)
- ORP (mV)
- Brix (%); *only Rounds 2 and 3*

Trends in analytical results for raw, treatment, and control (Soak 1 and 3) were analyzed to determine vermifiltration impact on Michigan Craft Beverage wastewater. The efficacy of wastewater treatment was to be primarily determined by a reduction in BOD but other parameters were also reviewed. Select photographs collected of the pilot test set-up and during testing can be available upon request from LEI.

Discussion of results and conclusions, indicating objectives

The process of land application itself had positive impacts on BOD and DO concentrations, as well as pH levels. There was little overall impact on sodium and chloride and inconclusive evaluation on nutrients, due to set-up. However, the additional impact of vermifiltration on these parameters would require additional analysis to determine if treatment and cost are effective at a larger scale. Additional discussion on some of these parameters is outlined below and Table 1 contains the results from all three rounds of this pilot scale test.

The BOD results in pilot test effluent show constituent reduction but the difference between treatment and control results are not significant. There is some seasonal variation in BOD treatment and additional testing should be conducted to determine long-term vermifiltration impact at a larger scale. Similarly, improvements in DO concentrations and pH levels were consistent in each test round but minimal difference between the treatment and control beds.

For total phosphorus and TIN, results were inconclusive and mostly resulted in increased concentrations. The land application or vermifiltration process did not inherently increase nutrient concentrations but the required bedding for seeding the worms at this scale were nutrient rich. It is evident that nutrients were then leached from the material during the application steps which increased the concentrations in the wastewater collected from both the treatment and control beds. An ongoing test set-up, where the nutrients can be primarily provided by the wastewater would provide better data to evaluate the potential impact (or potential reduction) in nutrients from this treatment process.

It should be noted that a significant positive impact, although not specifically measured in the analytical results, is the differences in soil quality throughout the study period. The treatment bed (containing worms) better maintained its ability to infiltrate wastewater and have an overall healthier visual appearance. The soil quality is important to maintain crop growth (for nutrient removal) and infiltration capacity (to limit ponding and runoff). This additional benefit could have a more substantial impact on wastewater quality when evaluated at a full scale.

This study clearly demonstrated positive impact of land application processes on wastewater, however additional factors should be considered for ongoing evaluation of the vermifiltration benefits on wastewater treatment. Additional recommendations include testing at a larger scale, testing with ongoing daily wastewater application (vs. distinct periods) and testing with a cover crop.

This study was not intended to encompass every sustainable approach to wastewater management via land application but was an initial evaluation on using designed natural processes to improve existing natural treatment processes. This area of study warrants continued evaluation as a more sustainable approach to wastewater management. Additional areas of study in this area could include alternative base and cover materials along with the vermifiltration.

The project was conducted consistent with the budget originally posed by LEI and approved by the MCBC of the State of Michigan which was $15,998.

Table 1 – Pilot Test Results; November 2023, February 2024 and July 2024

	Nov-23					Feb-24					Jul-24				
	Pre-soak	Treatment		Control		Pre-soak	Treatment		Control		Pre-soak	Treatment		Control	
		Soak 1	Soak 3	Soak 1	Soak 3		Soak 1	Soak 3	Soak 1	Soak 3		Soak 1	Soak 3	Soak 1	Soak 3
Metals Analysis (mg/L)															
Phosphorus, Total	7.6	26	72	65	24	19	24	25	15	16	14	21	29	14	16
Sodium, Total	82	53	92	100	50	170	150	140	180	140	160	160	150	170	150
Other Analysis (mg/L)															
Biochemical Oxygen Demand (BOD)	2300	2300	2000	1500	2800	6600	2900	4500	3800	4000	3700	250	1700	2300	1700
Chloride	<10	24	210	330	17	19	4	46	12	20	190	190	190	190	160
Nitrogen (Nitrate)	7.6	100	240	370	59	3.6	25	20	2.6	3	1.1	88	100	33	32
Nitrogen (Nitrite)	1.2	1.4	13	2.1	5.8	4.5	5.9	6	6.9	6.1	<0.20	0.66	6.9	1	7.2
Ammonia as Nitrogen	0.067	0.17	9.6	8.7	0.54	30	2.7	2.7	4.5	3.1	39	11	8.6	9.9	11
TIN (Calculated)	8.9	100	260	380	65	38	33	28	14	12	40	100	120	44	50
Field Readings															
Temperature (°C)	16.3	13	14.1	13.1	13.8	11.9	13.1	13.5	12.8	13.7	19.5	18.3	21.3	18	21.2
pH (s.u.)	5.12	6.86	7.2	7.1	7.33	5.64	6.8	7.26	6.55	7.16	4.87	6.63	7.27	6.78	7.17
Conductivity (µS/cm)	1149	5337	4207	1948	1785	1329	1546	1510	1337	1262	1813	2479	2611	2036	1912
Dissolved Oxygen (DO)	0.07	4.42	6.55	5.1	6.78	2.32	6.56	7.54	6.58	6.77	0.6	1.4	1.92	1.4	1.7
ORP (mV)	174.1	122.3	99.3	100.4	88.3	122.9	135.7	164.6	139.3	174.8	-66.3	96.9	102.9	101	95.8
Brix (%)	-	-	-	-	-	0.4	0.4	0.4	0.4	0.3	0.5	0.5	0.5	0.5	0.4

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