Evaluation of Spent Grain Biochar for Effluent Remediation

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Abstract

In recent years, industries have become aware of their impact on the environment and their surrounding communities. The Brewers Association, for example, recently published a manual on the handling of brewery effluent. In this project, we explored the use of Brewers Spent Grain (BSG) to treat model effluent. Biochar was generated from BSG to produce a carbon rich that was used to filter regular tap water and typical brewery effluent. Total Dissolved Solids (TDS) were measured from treated solutions as an indicator of the filter capacity of the biochar. Data obtained from this pilot project seems promising and meaningful in that a decrease of 3.35% and 19.5% for tap water and model effluent was observed. We conclude that use of biochar from BSG in treating effluent can be helpful in reducing TDS. This can help reduce the stress put on the environment from industrial effluents. Further study would involve communicating these results to surrounding industries in addition to analyzing use of their solid wastes to generate biochar for effluent treatment.

Introduction

Depending on the alcohol content, most beer is approximately 95% water and it is estimated that 1 gallon of beer requires up to 7 gallons of water to produce. This offers brewers a significant opportunity to contribute to water conservation and quality in their respective communities. In 2015, the Brewers Association published a ground-breaking manual on brewery water and wastewater treatment, but there is still so much more work to be done in this area.

Breweries need to be commended for their efforts to reduce the effect of wastewater on their communities. If they were able to generate their own filtration methods to be employed on-site this could greatly enhance their ability to influence wastewater characteristics coming from their production facilities.

One part of the solution could actually be obtained from the use of solid waste products in the brewery, namely spent grains. This study evaluated the use of spent grains and, more specifically, spent grain biochar, to reduce total dissolved solids (TDS) in fresh tap water and model effluent.

Spent grain biochar was generated using a muffle furnace heated up to 600 ºC and ramped back down to room temperature. Nominal treatment of 10 minutes demonstrated little reduction in TDS and, as a result, overnight stirring at 240 rpm was evaluated.

Methods

- Spent grain was obtained from local breweries and placed in open air to dry.
- Air-dried spent grain was further dried at 105 ºC for 2 hours.
- Fully dried grains were milled to a coarse powder using a grinder.
- Resulting grains were placed in a muffle furnace using the following schedule:
  - 200 ºC for 1 hour
  - 400 ºC for 1 hour
  - 600 ºC for 1 hour
  - 400 ºC for 1 hour
  - 200 ºC for 1 hour
  - Cooling at room temperature for 1 hour
- Three grams of biochar were used for various treatment methods
- Treatments were evaluated for Total Dissolved Solids using a meter (n=6)

Results Section

Initial Evaluation

Water Treatment	Before Treatment	After Treatment
No Biochar	472	474
Poured over Biochar	472	466
10 minute Biochar Exposure	472	464
Spent grain, 10 min	472	483
Milled spent grain, 10 min	472	492

Fresh tap water was used to evaluate nominal exposure to biochar and effect of on TDS reduction (Average of three trials).

Biochar Treatment Evaluation

Water Treatment Stirring overnight @ 240 rpm	Before Treatment	After Treatment
Fresh Biochar	432 ± 1.9	379 ± 7.7
Regenerated Biochar	432 ± 1.9	359 ± 3.2
Plastic Tube Storage of Biochar	410 ± 2.2	406 ± 2.9
Fresh Biochar (Repeat)	438 ± 4.5	397 ± 2.7
Model Effluent	3280	2640 ± 25.1

With the exception of model effluent, treatment consisted of tap water being exposed to biochar. All

- Biochar was regenerated through rinsing and repeated muffle furnace treatment
- Model effluent was generated using a common solution used during the brewing process

Reported as mean ± S.E.M.

Figure 1 Muffle Furnace

Figure 2 Biochar

Figure 3 Spent Brewery Grain

Summary of Results

- Nominal exposure to biochar, Spent Grains and Milled Spent Grains did not produce any reduction in TDS
- Regenerated biochar generated similar reductions in TDS as fresh biochar
- Storage of biochar in plastic tubes negated any TDS reduction
- Biochar reduced TDS in model effluent by 19.5%

Results & Discussion

•Ten minute exposure to biochar was insufficient for TDS reduction
•Spent grain and milled spent grain offered no reduction in TDS. These were also evaluated using overnight stirring @240 rpm which resulted in an increase in TDS (not shown).
•Regenerated biochar offered similar TDS reduction values
•Plastic tube storage of biochar results in a loss of TDS reduction. This is likely due to negative charges on the biochar.or plastic tubes.
•Biochar reduces TDS in model effluent by approximately 19.5%.

Future Studies

•Evaluate other model effluent solutions
•Study surface characteristics of spent grain biochar
•Evaluate other biochar treatment methods

References

1. Treatment of brewery industrial wastewater and generation of sustainable bioelectricity by microbial fuel cell inoculated with locally isolated microorganisms. J Water Proc Eng 41: 10218 1-7 (2021)
2. Water and Wastewater: Treatment/Volume Reduction Manual. Brewers Association. (2015)
3. Characterization of Brewery Wastewater Composition. Int J Env Ecol Eng 9: (9) 1073 – 1076 (2015)
4. Sustainable mechanisms of biochar derived from brewers' spent grain and sewage sludge for ammonia–nitrogen capture *J Cleaner Prod*, 112, 3927-3934 (2016).

Acknowledgements

I would like to thank the Welch Foundation (Grant # AE-0025) for support of this research.

I would also like to thank the local breweries who provided spent grain for this project.