Use of Biochar in Live Streams and Lakes on Mine, Municipal and Private Lands

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August 2022

Background

- **Acer Environmental, LLC. (Acer) has experience working with aquatic restoration for mitigation, stormwater and wastewater.**
- **Specialized in the restoration of benthic macroinvertebrates.**
- **Started working with Biochar about 8 years ago.**
- **Been conducting field test with Biochar to remediate contaminants and nutrients in various types of aquatic environments.**
- **Conducted field test on ponds and streams in coal mines, municipal waters, farm ponds, streams and detention ponds.**

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Background

- **Acer has tested numerous varieties of Biochar from all over the country.**
- **Testing was conducted by the UGA Water and Soils Laboratory by either infiltration column test or was shaken/spun with an analyte for 16 hours.**
- **Testing found:**
  - **Biochar tested was inconsistent in look, size and moisture content.**
  - **Many Biochars shed nitrogen and phosphorus.**
  - **Adsorption for nitrogen, phosphorous and other heavy metals is not as high as advertised.**

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Case Study: Removal of Aluminum

- Project included treating water leaving two treatment ponds that had Aluminum levels that were 9.7 mg/l.
- WVDEQ limits for Aluminum are 4.0 mg/l limit.
- Initially added Biochar to the water but no adsorption occurred.
- Discovered pH was below pH of 3.
- Caustic soda was added to the water to neutralize the pH.
- Once the caustic brought the pH up above a pH of 4, the levels of Aluminum in the water started to reduce.
- When the pH reached neutral and above the levels of Aluminum in the water were reduced to 0.3 mg/l.
- Socks/bag lasted in the ponds for over 8 months, initially.
- Fouling due to a flocculant created from adding the caustic soda to the water eventually clogged up the bags, preventing the flow of water through the bags.
- Biochar bags/socks utilized a rice grain biochar with one-third of the material being shredded wood. We used the wood because the small biochar tended become compacted. The wood was used to aid in allowing water to move through the material.
- Replacement bags have been in place for five years without problems. One set had to be replaced because it was washed away by a storm.

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Case Study: Removal of Aluminum

Biochar Bags in Coir Fabric at Two Different Pond Outlets

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Case Study: Removal of Selenium

- Water leaving three different treatment ponds had Selenium levels that were over 10 mg/l.
- WVDEQ limits for Aluminum are 4.7 mg/l limit.
- We utilized a series of socks/bags wrapped around the outlet that were 1-foot by 20 feet were stacked on top of each other at the outlet of each pond.
- Additional 20 bags that were 8 inches by 48 inches were floated through out the ponds.
- Selenium levels were reduced to less than 2 mg/l.
- The bags placed in the pond stopped an algal bloom that was occurring in approximately 3 weeks of installation.
- Bags are still in the water and had lasted for over 5 years keeping the Selenium levels below required levels.
- We recently replaced bags because they were lost to a storm.

Case Study: Removal of Selenium

Biochar Bags at Pond Outlet

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Case Study: Removal of Selenium

Biochar Bags in a Pond Outlet

Case Study: Removal of Nitrogen & Phosphorus

- **The socks/bags floated in a pond in WV stopped an algal bloom that was occurring in approximately 3 weeks of installation.**
- **A five-acre pond in South Georgia has over 500-acres of farmland upstream. Prior to treatment this pond had an algal bloom that started in May and ended at the end of October. Then in June of 2017 the owner installed 10 socks/bags that were 8 inches by 48 inches. The results are:**
  - **2017 – Socks/bags were installed in June and after one month the algal bloom had disappeared. No further algal blooms all year.**
  - **2018 – Socks/bags remain in the pond. No algal blooms all year.**
  - **2019 – Socks/bags remain in the pond. Pond turns clear and owner can see the bottom of the pond and fish. Half of the socks/bags are removed. Lake returns to green color and no algal blooms all year.**
  - **2020 – Socks/bags remain in the pond today and small patches of algae started to occur late summer/early fall this year. Color has remained the green.**
  - **2021 – Replaced 4 bags in June. No signs of algal blooms.**

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Case Study: Removal of Nitrogen and Phosphorus

- Utilize silt sock.
- Can be wrapped in coir fabric to filter off larger particles.
- Floats are plastic cannon balls or any type of plastic/rubber ball.
- Attach paracord to bottom and tie it off to a concrete block.
- Located mostly at the inflow of the pond.
- Can be located over bubblers or other water dispersion device.
- Can be attached to floating vegetation island.

Biochar in Silt Sock (8 inches by 48 inches)

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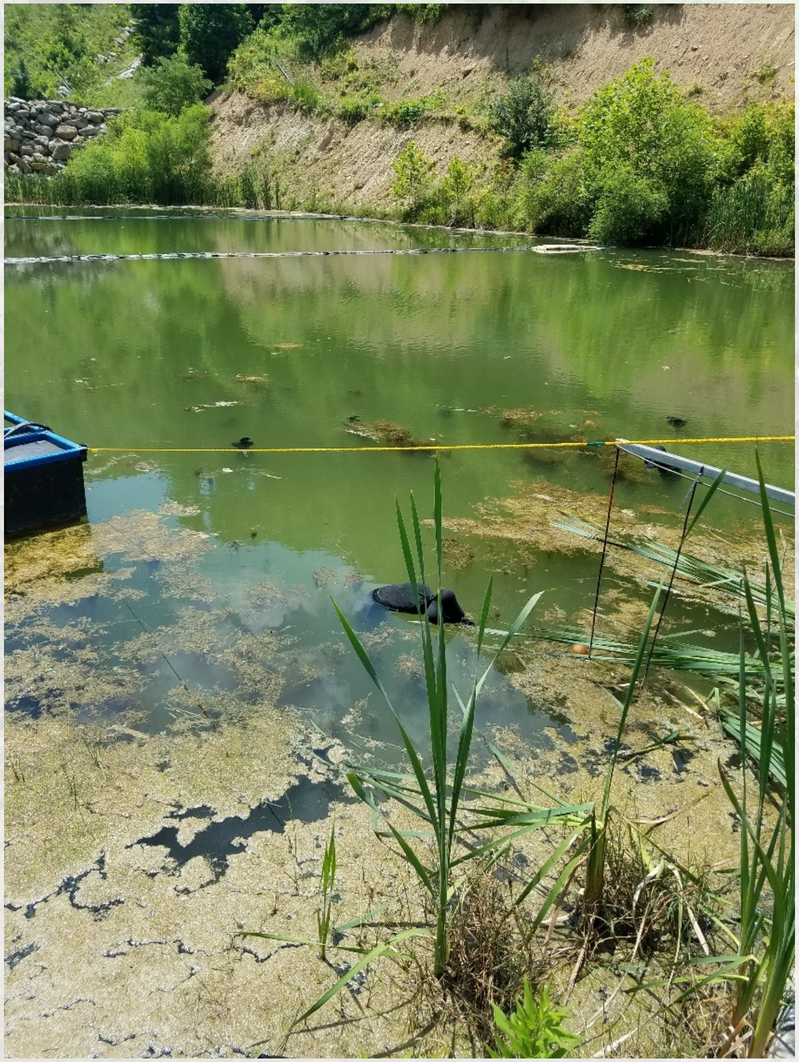
Case Study: Removal of Nitrogen & Phosphorus



Biochar Tubes Floating in a Pond

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Case Study: Removal of Nitrogen & Phosphorus

South Georgia Ponds Before & After Biochar Bags are Added

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Case Study: Prince William County, VA

- **Installed Biochar at outfalls to two treatment ponds at a wood recycling facility and landfill.**
- **At wood recycling facility, initial sampling showed a reduction in BOD, phosphorus and nitrogen. The materials in the water causing the high BOD quickly overwhelmed the Biochar in the bags stopping it from adsorbing any additional materials.**
- **The landfill site results found:**
  - **Phosphorus was reduced from 0.8 mg/l to 0.2 mg/l**
  - **BOD was reduced from over 35 mg/l to 4.0 mg/l**
  - **Escherichia coli was reduced from 2,419 CFU/100 ml to 344 CFU/100 ml**
  - **TKN was reduced from 4 mg/l to 2 mg/l**
  - **Not all of the water was filtered during this project.**

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Case Study: Prince William County, VA

Biochar Bags Below Treatment Pond Outlet

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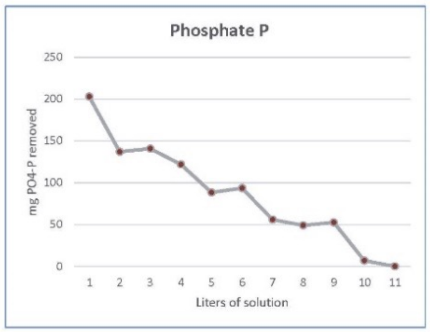
Carrying Capacity Studies – Phosphorous & Selenium

Phosphate Sorption as PO_4-P	Solution: KH_2PO_4 500 mg/L pH 6.8
Lab ID: SP400-409	One liter filtered through 500 g biochar per day

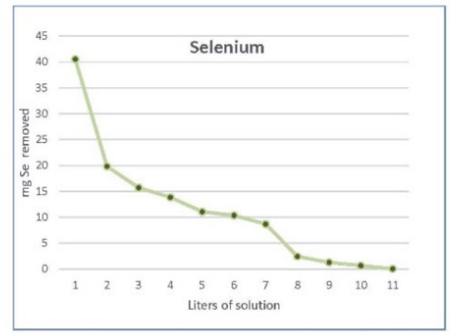
Phosphate	
PO_4-P	
Liters of solution	mg removed
1	203
2	137
3	141
4	122
5	88
6	93
7	56
8	49
9	53
10	7
11	0



Amount of PO_4-P removed (grams)	
Grams of PO_4-P removed per kilogram biochar	1.9
Grams of PO_4-P removed per cubic foot biochar	11.8
Grams of PO_4-P removed per cubic yard biochar	319.2

Selenium Sorption	Solution: Na_2SeO_3 100 mg/L pH 6.9
Lab ID: SP410-419	One liter filtered through 500 g biochar per day

Selenium	
Se	
Liters of solution	mg removed
1	40.5
2	19.8
3	15.7
4	13.9
5	11.1
6	10.4
7	8.7
8	2.5
9	1.3
10	0.7
11	0.044



Amount of Selenium removed (grams)	
Grams of Se removed per kilogram biochar	0.25
Grams of Se removed per cubic foot biochar	1.6
Grams of Se removed per cubic yard biochar	41.9

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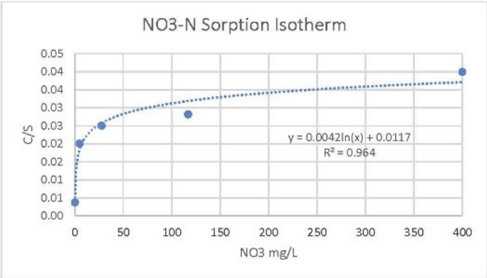
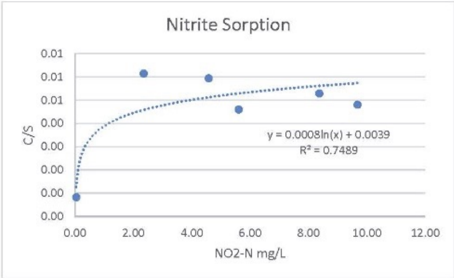
Carrying Capacity Studies -- Nitrogen



NO₃-N Maxima (mg/kg)	238.1

Calculations	
Assumed bulk density (g/cm^3)	0.22
cubic ft (kg)	6.2
cubic ft (lbs)	13.7
g NO_3-N sorbed per cubic ft	1.48
lbs NO_3-N sorbed per cubic ft	0.00327



NO_2-N Maxima (mg/kg)	1250

Calculations	
Assumed bulk density (g/cm^3)	0.22
cubic ft (kg)	6.2
cubic ft (lbs)	13.7
g NO_3-N sorbed per cubic ft	7.78
lbs NO_3-N sorbed per cubic ft	0.0172

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Studies of Interest

- **Dupont Study in Front Royal, VA on the South River utilizing Biochar to prevent mercury from entering the river.**
- **Virginia Tech study on bioreactors.**
- **Rice Biochar receiving NSF certification for use in drinking water.**
- **Appalachian State University is using coir materials and Biochar with mycelium to remediate nutrient loads in streams.**
- **Terra Char is being used in clean up of ponds. They have been conducting limited testing on ponds in Missouri and has stopped algal blooms in a one-month period.**
- **Princeton Hydro studies to stop algal blooms.**

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What is Needed in the Future

- **More studies need to conducted in real world conditions with commercially available biochar.**
- **A larger sample size of lakes and treatment ponds needs to conducted.**
- **We need to understand the interaction of microbes and mycelium with Biochar in the field.**
- **More work needs to be conducted with Biochar in bioreactors for phosphorous, nitrogen, selenium, etc.**
- **Biochar needs to be tested with sediment in streams to determine how it can be sorted in the bed and sequester legacy contaminants.**
- **More types of test such as column test which have real world applications, need to be conducted on Biochar by laboratories.**
- **More carrying capacity testing**
- **Individual producers of Biochar need to conduct more testing of their products and post those results.**

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