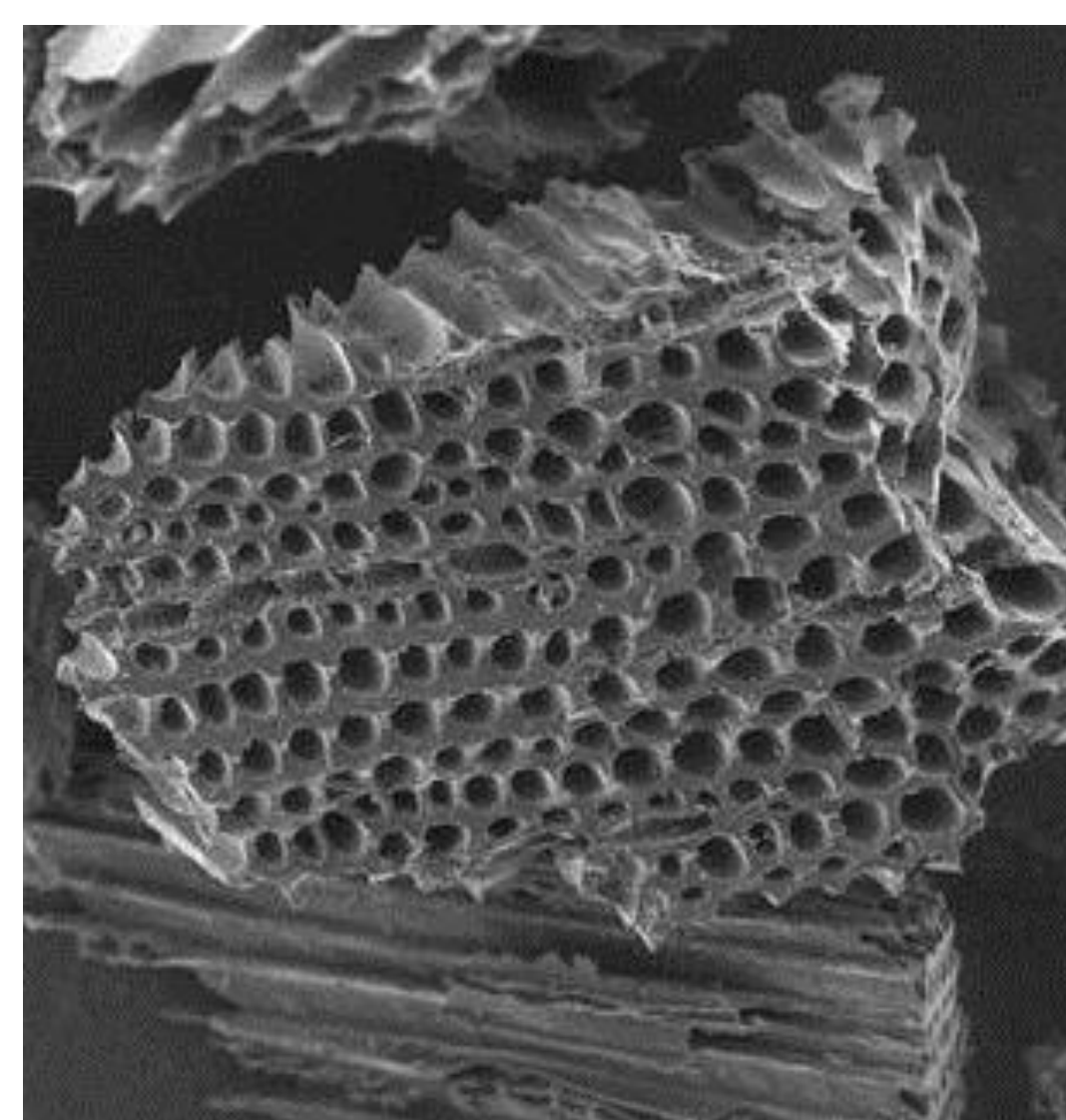


## 1. Problem

- Stormwater management is a growing concern nationwide, with lower discharge limits for many common pollutants including copper and zinc
- Current technologies for removing dissolved copper and zinc are either prohibitively expensive or are not effective enough to meet discharge benchmarks
- Low-cost, effective alternative treatment is needed

## 2. Biochar as Solution

- Biochar is a carbon-negative charcoal-like material that is a byproduct of renewable bioenergy production
- Biochar has unique properties including incredible surface area as high as 300 m<sup>2</sup>/g that endows the material with strong sorption capabilities
- Research shows that biochar can remove multiple contaminants from water:
  - Heavy metals: Pb, Zn, Cu, Cd,
  - Organics: PAHs, PCBs, VOCs, etc.
  - Nutrients



SEM image of Douglas-fir Biochar

## 3. Sunmark: Initial Installations

- Beginning in 2010, Sunmark in conjunction with BioLogical Carbon, LLC have developed and installed Earthlite™ biochar-based stormwater treatment media and RainClear™ filtration devices
- Results from these installations have shown encouraging, but variable results for removal of heavy metals



RainClear™ filtration device

Heavy metals removal rates for RainClear™ filtration devices using Earthlite™ media

| Removal Rate | Copper | Zinc | Lead |
|--------------|--------|------|------|
| Mean (%)     | 90%    | 51%  | 95%  |
| Maximum (%)  | 99%    | 95%  | 99%  |
| Minimum (%)  | 48%    | 25%  | 79%  |

## 4. OregonBEST Optimization Project

- To improve performance and consistency of biochar-based stormwater filtration media, OregonBEST™ has provided funding to Oregon State University to complete a rigorous product development and optimization project in conjunction with Sunmark and BioLogical Carbon
- Given the current challenges in stormwater treatment, this project will focus primarily on copper and zinc removal
- Project goals** include optimization of biochar-based stormwater **filtration media**, design and optimization of suitable **filtration devices**, rigorous **pilot testing**, and **outreach and commercialization**
- Project goals will be achieved in 4 phases:

### Phase 1: Biochar characterization

- Characterize copper and zinc removal of available biochars to select the most effective for further testing
- Investigate other biochar properties relevant for filtration and will seek to create a rapid screening protocol for new biochars

### Phase 2: Secondary component characterization

- Characterize copper and zinc removal of secondary (non-biochar) filter media components and select those components that are most effective
- Secondary components will include both mineral and organic components, some of which are currently used in the Earthlite™ filtration media

### Phase 3: Complete filtration media characterization

- Create and test multiple complete media filtration mixtures using most effective components from Phases 1 & 2
- Select most effective complete filtration mixture
- Complete rigorous testing of selected media mixture to determine flow rate properties, filter lifetime, spent filter toxicity, and contaminant removal rates for numerous contaminants including heavy metals, TSS, hydrocarbons, and BODs

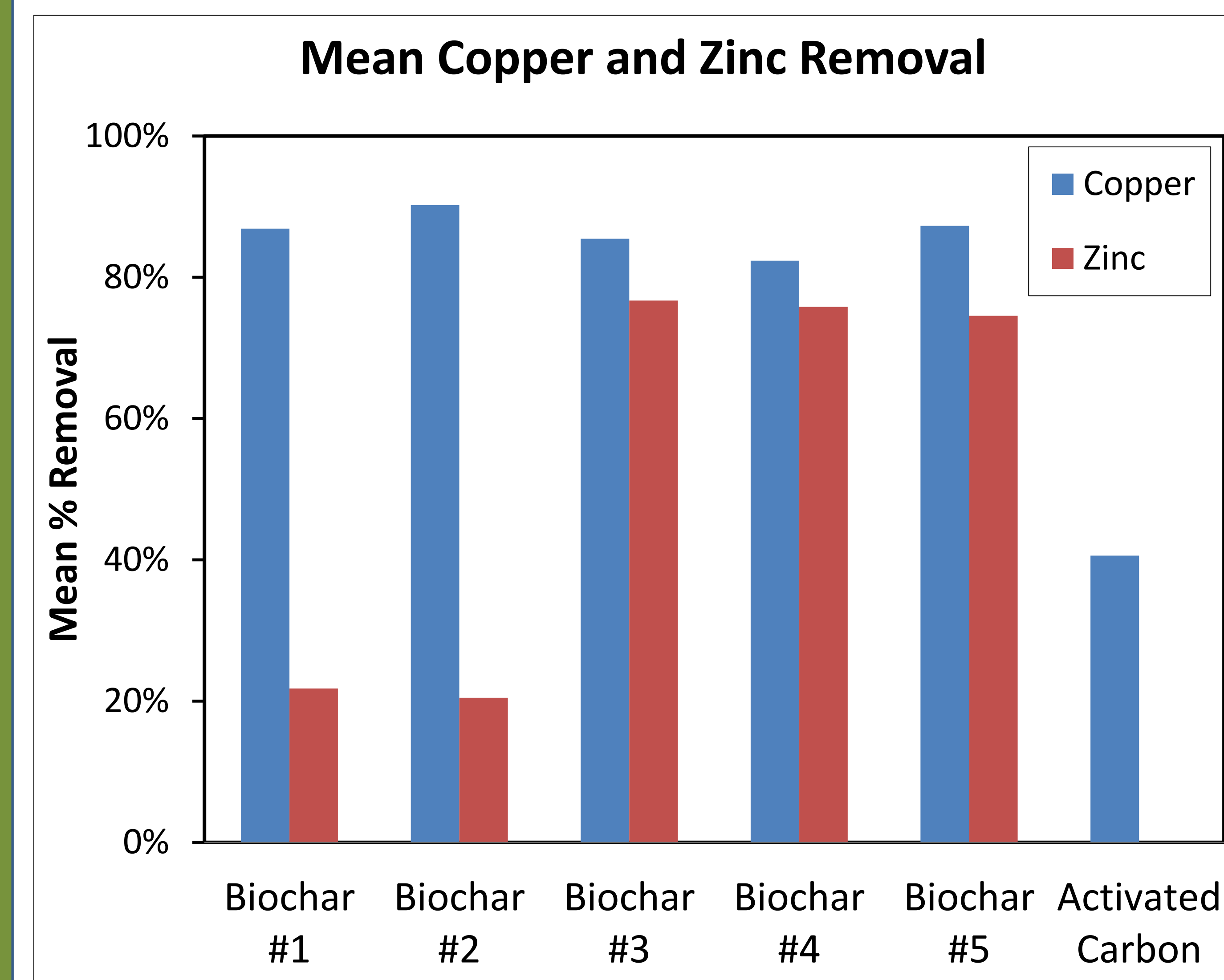
### Phase 4: Filtration device pilot testing

- Design and construct suitable filtration devices including downspout totes, above-ground totes, filter bags, etc.
- Install and rigorously monitor pilot installations

## 5. Phase 1 Results

### Copper and Zinc Removal

- Five biochars and activated carbon were assessed for zinc and copper removal using batch trials of synthetic stormwater with concentrations from 0.05 to 2 mg/L
- All biochars exhibit excellent copper removal capacity, with more variable zinc removal
- All biochars were more effective than activated carbon at removing both copper and zinc



### Particle Size Distribution

- Particle size distributions indicate that all biochars would need to be rinsed or sieved prior to use in high-flow filtration applications
- Some biochars are composed primarily of fine particles and may not be suitable for filtration

## 6. Conclusions and Project Schedule

- All tested biochars show high capacity to remove copper, with variable zinc removal
- Phase 2 characterization has begun with initial results showing that some secondary components may provide synergistic effects when combined with biochars
- The project schedule calls for media characterization to be completed the end of 2014 with pilot projects installed during the 2014-15 rainy season
- Optimized filtration media and filtration devices will be available from Sunmark Environmental, LLC, Portland, OR [www.earth-lite.com](http://www.earth-lite.com) or (503) 241-7333