Environmental Enhancement Through Corn Stover Utilization

Evaluating the Recycling of Biochar as a Co-product of Pyrolysis: pH and microbial effects.

by

D.C. Reicosky

USDA

Agricultural Research Service

USDA-ARS-MWA

North Central Soil Conservation Research Laboratory Morris, MN USA

don.reicosky@ars.usda.gov

Acknowledgments:

Robert Brown, PI and Justinus Agus Budi Satrio, provided corn stover and biochar

Seth Miller, Jay Hanson, Jana Rinke, Chris Wente, technical support

BEST Energies, provided corn stover char

Jeff Strock, provided turkey manure ash

Robert Hawkins, Danny Day, provided pine, peanut hull, and corn stover char

David Laird, provided Oak/Hickory charcoal

Jeff Novak, nutrient analysis and SEM photographs

Jon Nilsson, Char Carbon Group, provided Pine char plus compost

Co-products from bio-energy production as potential soil amendments?

Lignin from cellulosic fermentation can make fertile soil?

Corn stover high lignin

Ash from Gasification can make fertile soil?

Turkey Manure + woodchips

Char from pyrolysis can make fertile soil?

Iowa Corn Stover Char

All bio-energy co-products are not created equal!

General objective: to evaluate the diversity in properties of bio-energy co-products as potential soil amendments.

Specific Objectives:

To determine effect of biochar/ash on pH in soils with different soil organic matter contents.

To determine the effect of biochar on microbial activity as measured by CO_2 evolution in laboratory incubation studies.

To determine the content and availability of the nutrients in bio-energy co-products.

Abbreviations Used

- C = Cecil Soil
- BE = Barnes Eroded soil
- BNE = Barnes Non-Eroded soil

Char Description

1. "Australian corn stover char" (ACC)
2. “EPRIDA pine char 2007” (PC)
3. “EPRIDA peanut hull char 2007" (PHC)
4. "Iowa corn stover char (Iowa)" (ICC)
5. "EPRIDA corn stover char (Iowa)" (IC8)
6. "BioSource" (BS) pine char + compost
7. "Turkey manure ash (+ wood chips)" (TM)
8. “Oak/Hickory charcoal" (OH)
9. "EPRIDA pine char 2008" (PC8)
10. "EPRIDA weathered peanut hull char" (WC)
11. "EPRIDA corn stover char (Iowa) 2008" (CS500)
12. " EPRIDA corn stover char (Iowa) + pressure 2008" (CS500P)

Wanted to apply char at 10 times the amount of carbon removed in corn stover in one year.

Assumptions used in char application rate:

12544 kg ha^{-1} grain yield (200 bu ac^{-1})

Harvest Index = 0.53

Stover yield = dry 9.455 t ha^{-1} (4.221 ton ac^{-1})

C content of stover = 46%

C content of char = 75% (Bob Hawkins)

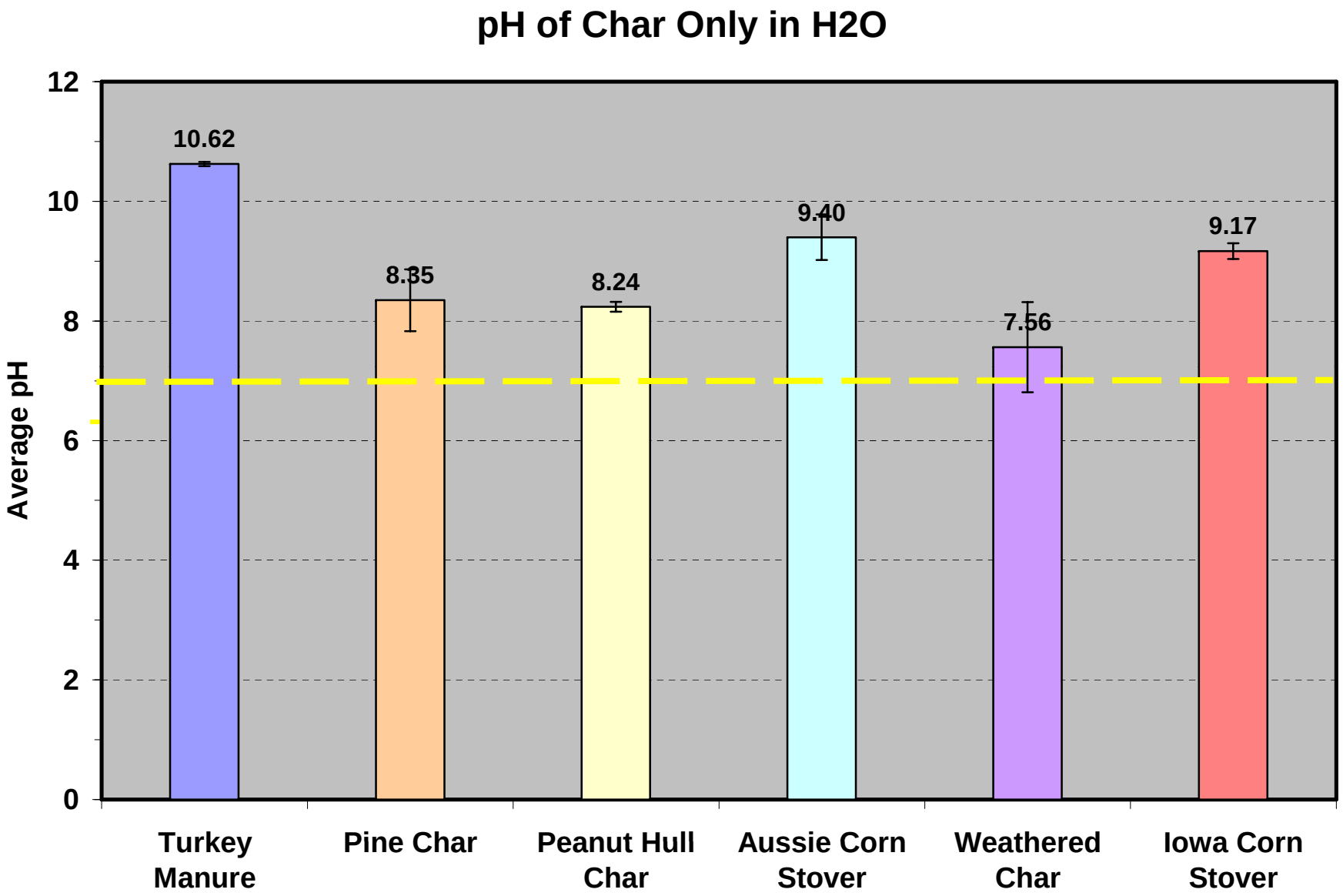
1X = 2.589 g char kg^{-1} soil, 10X = 25.89 g char kg^{-1} soil

1X = 5799 kg char ha^{-1},(2.589 t char ac^{-1})

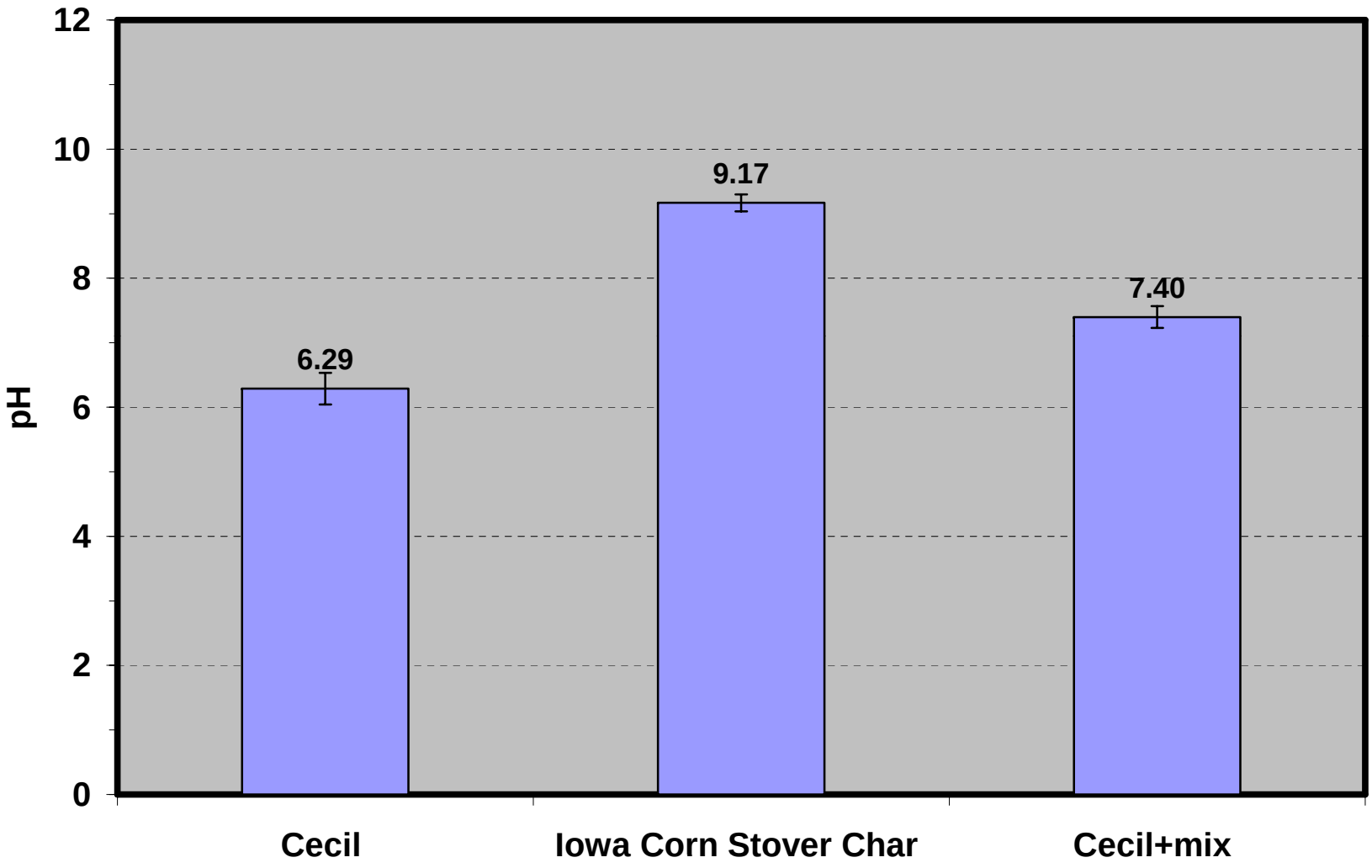
10X = 57990 kg char ha^{-1}

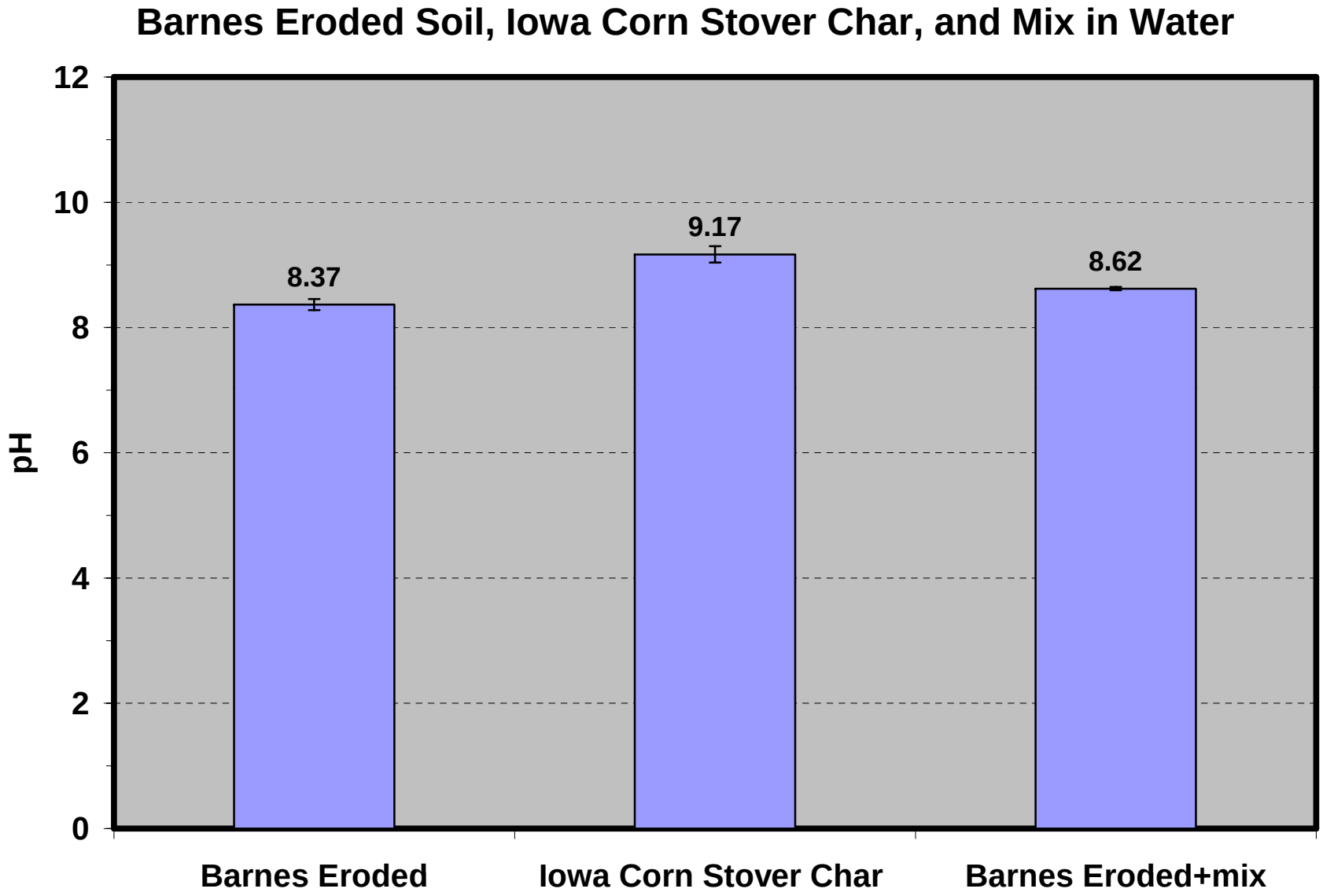
pH Study

- Soils, chars alone and mixed
- 5 g of soil, 10 ml H_2O per sample
- 0.129 g of char per 5 g soil mixture
- Meter calibrated using standards of pH 7 and pH 10
- pH Measurements taken before and after the addition of $CaCl_2$


pH of Char Only in H2O
Average pH
12
10
8
6
4
2
0
10.62
8.35
8.24
9.40
7.56
9.17
Turkey Manure
Pine Char
Peanut Hull Char
Aussie Corn Stover
Weathered Char
Iowa Corn Stover

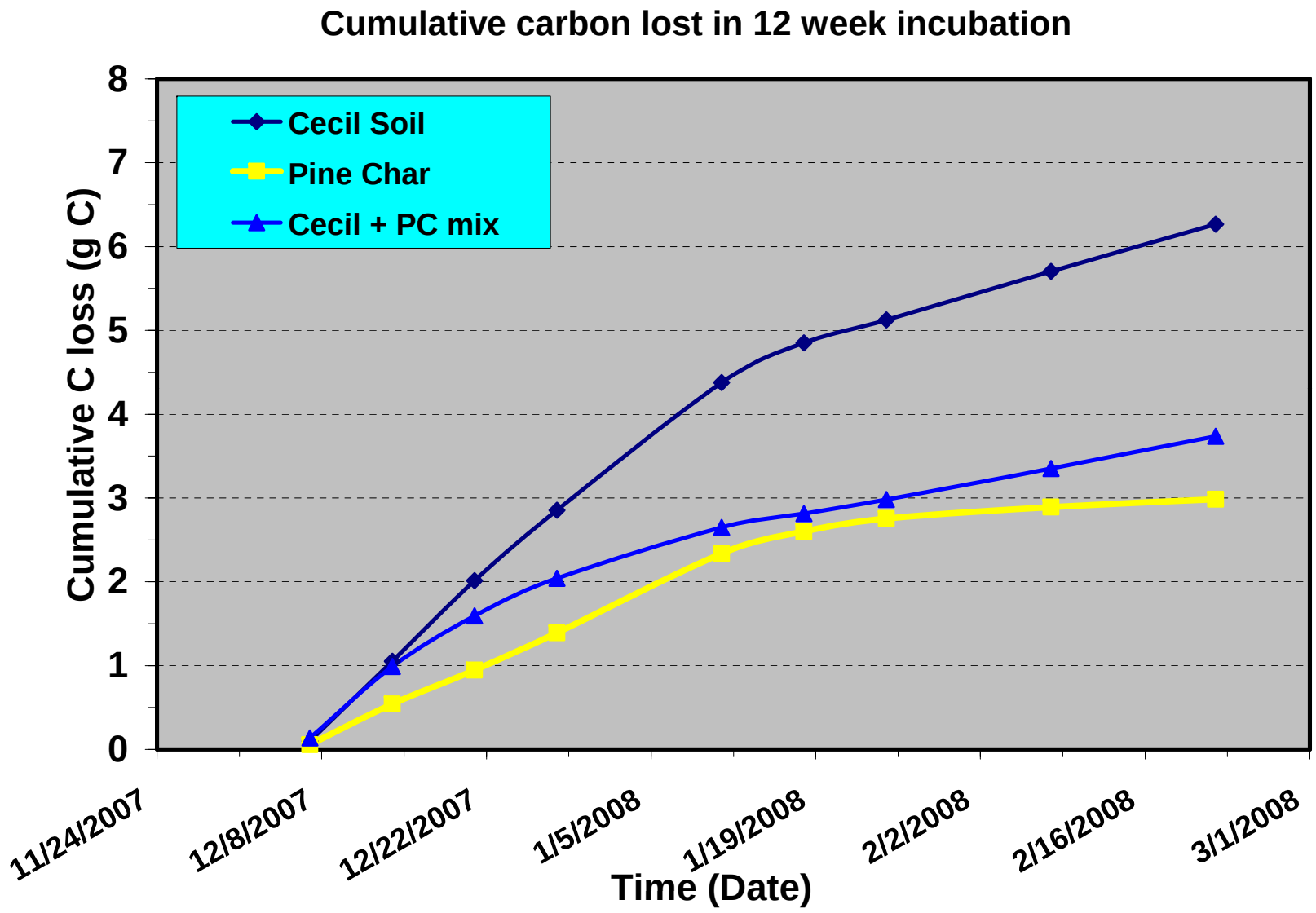
Cecil Soil, Iowa Corn Stover Char, and CICC Mix in Water

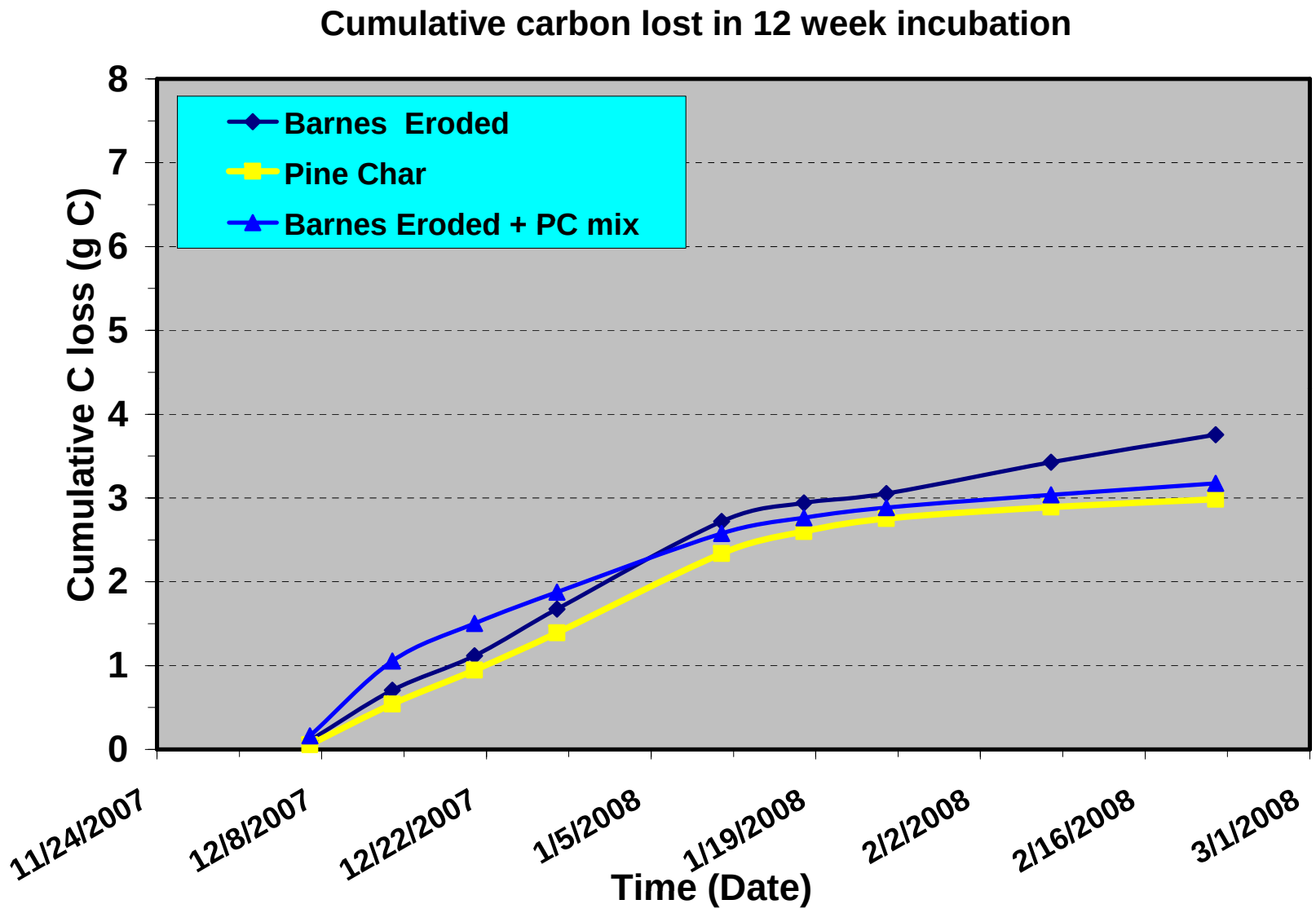



Barnes Eroded Soil, Iowa Corn Stover Char, and Mix in Water
pH
12
10
8
6
4
2
0
8.37
9.17
8.62
Barnes Eroded
Iowa Corn Stover Char
Barnes Eroded+mix

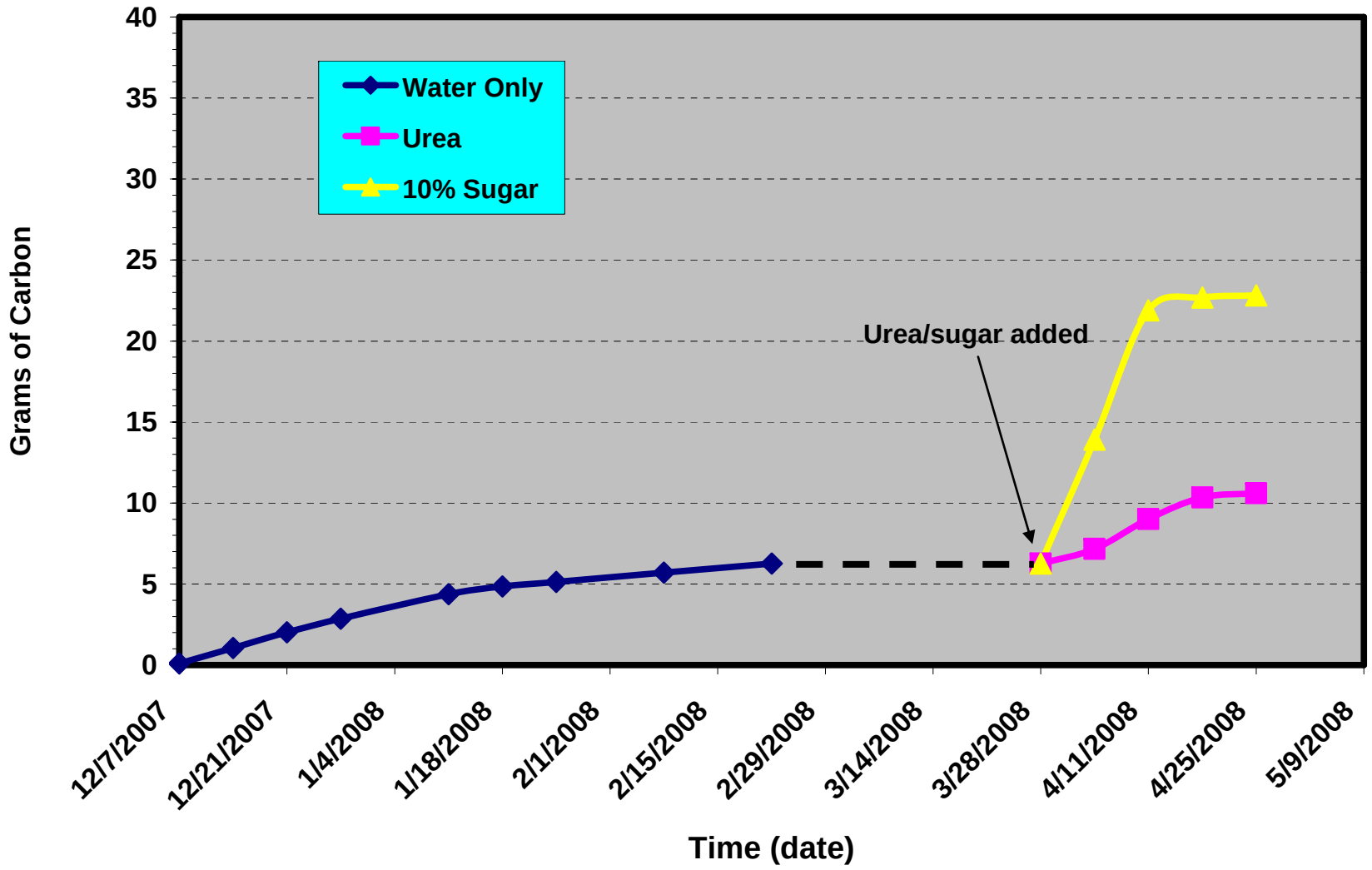
Incubation Study @ 25 C:

- 50 grams of soil sample in vial
- 1.29 grams of char = 10X rate C in 1 year stover yield
- Brought to Field Capacity with MQ water (~ 16 ml each)
- Weekly monitoring of CO_2 using a GC and amount of water in samples.

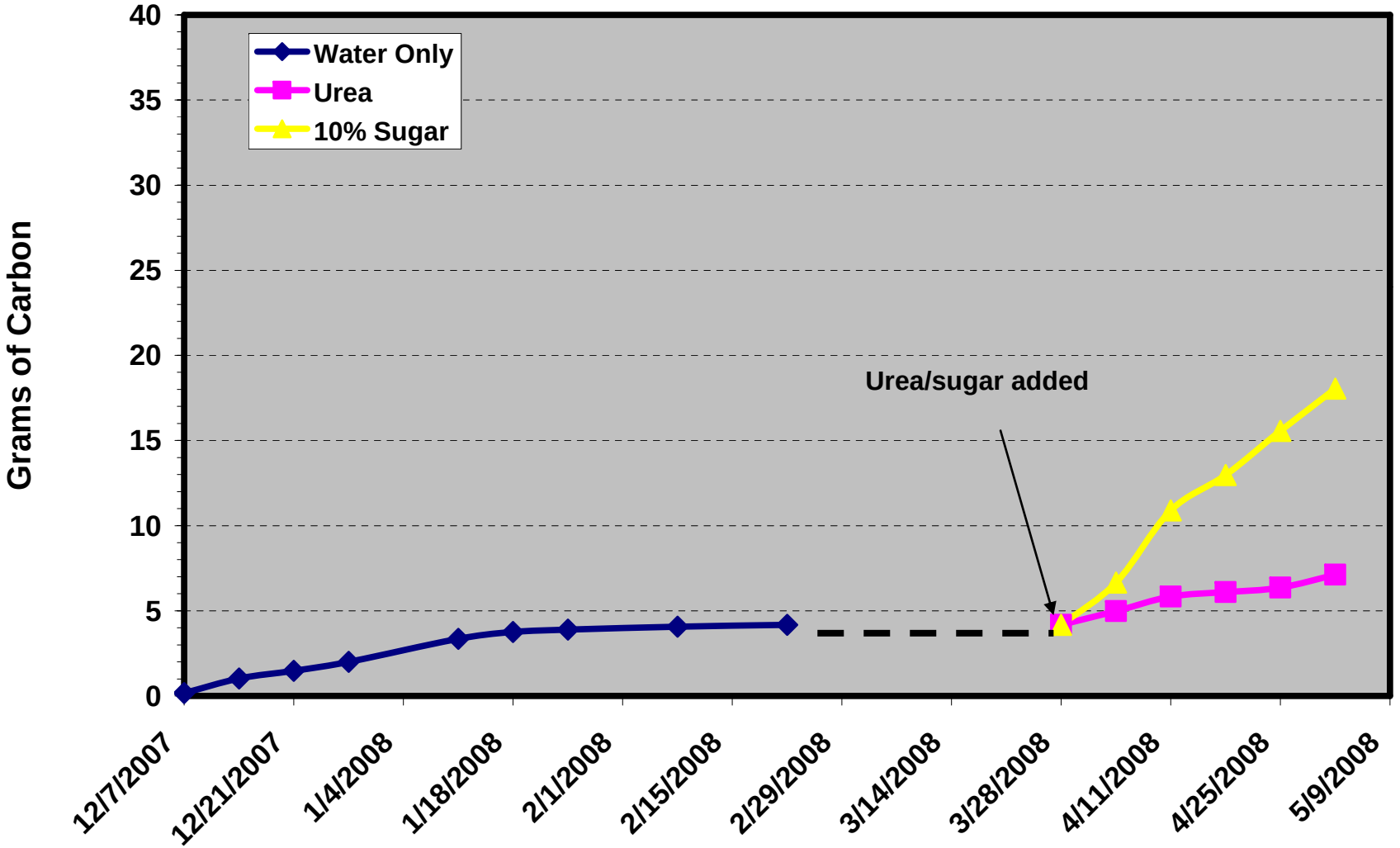

Cumulative carbon lost in 12 week incubation
Cecil Soil
Pine Char
Cecil + PC mix
Cumulative C loss (g C)
0
1
2
3
4
5
6
7
8
11/24/2007
12/8/2007
12/22/2007
1/5/2008
1/19/2008
2/2/2008
2/16/2008
3/1/2008
Time (Date)


Cumulative carbon lost in 12 week incubation
Barnes Eroded
Pine Char
Barnes Eroded + PC mix
Cumulative C loss (g C)
0
1
2
3
4
5
6
7
8
11/24/2007
12/8/2007
12/22/2007
1/5/2008
1/19/2008
2/2/2008
2/16/2008
3/1/2008
Time (Date)

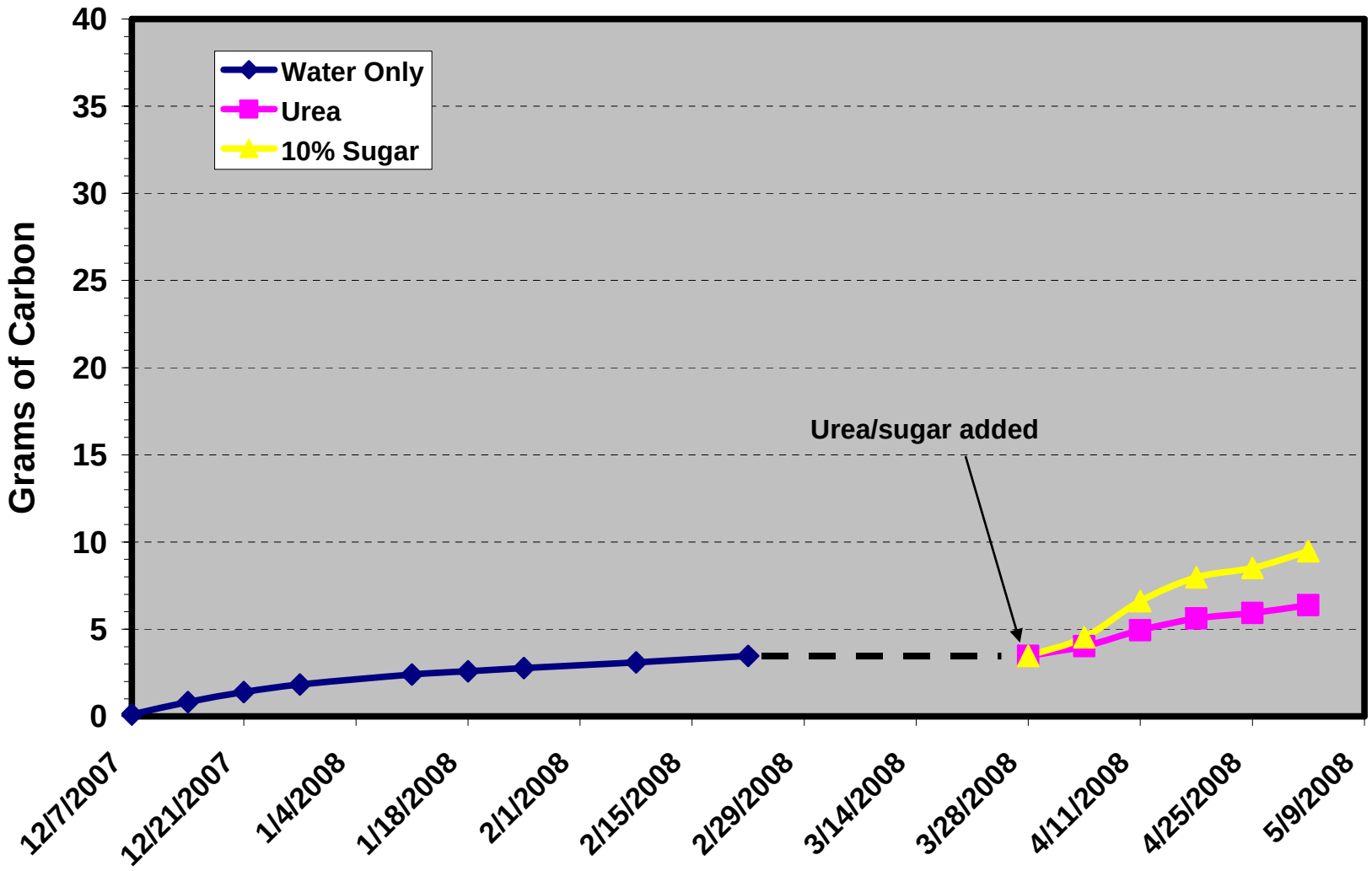
Cumulative Carbon Loss on Cecil Soil

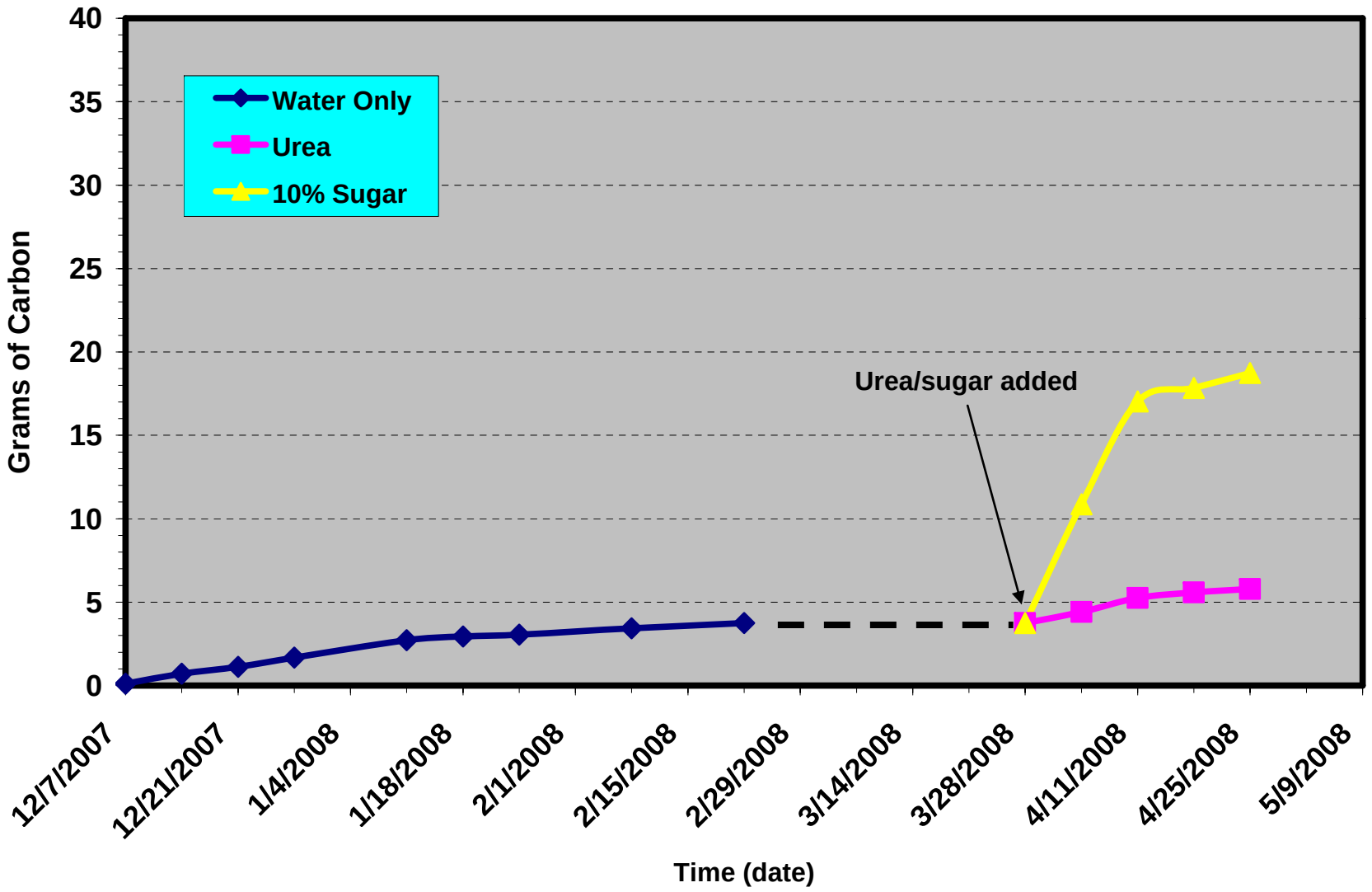


Cumulative Carbon Loss in Cecil/Turkey Manure Mix

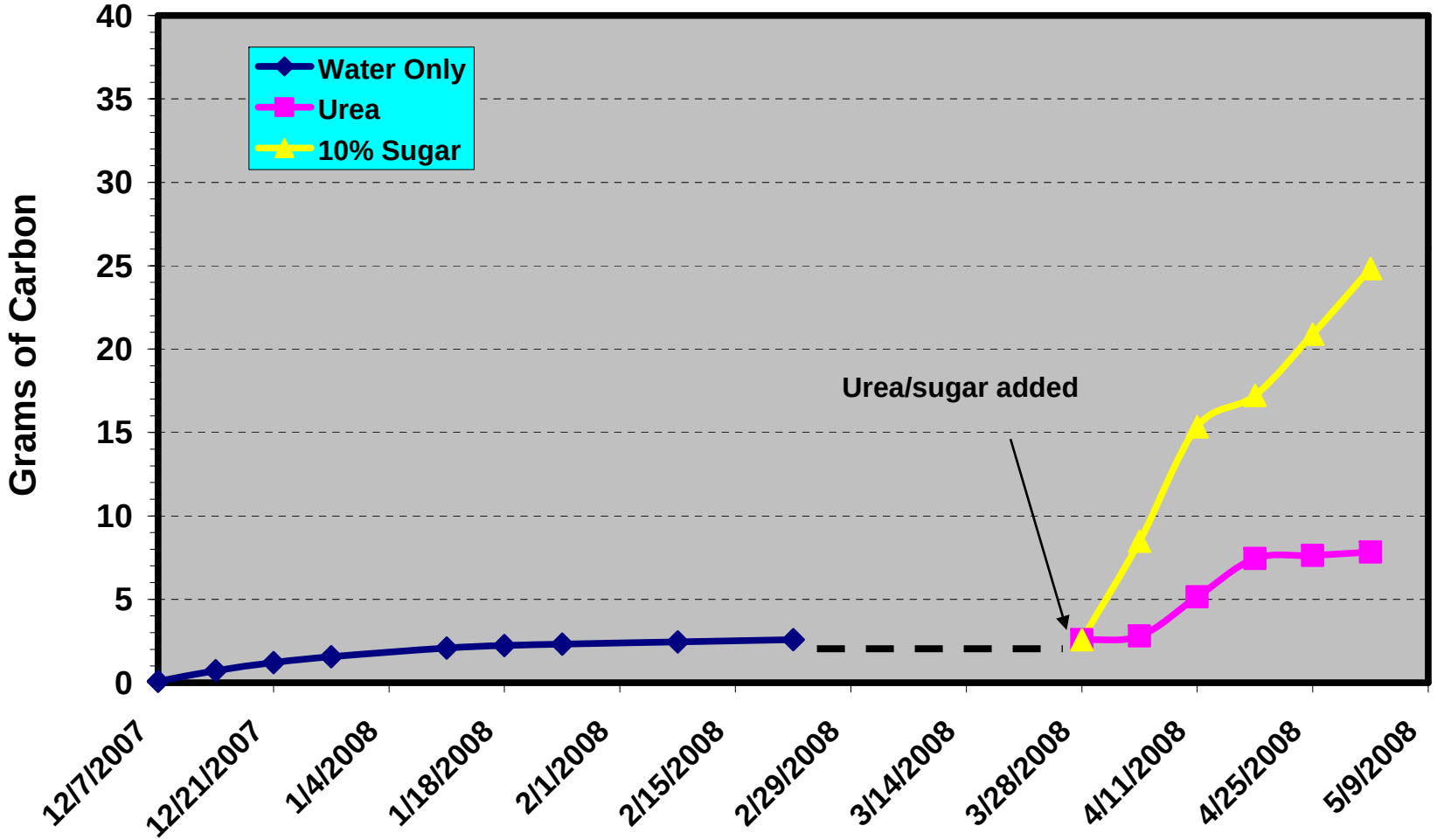


Cumulative Carbon Loss in Cecil/Australian Corn Char

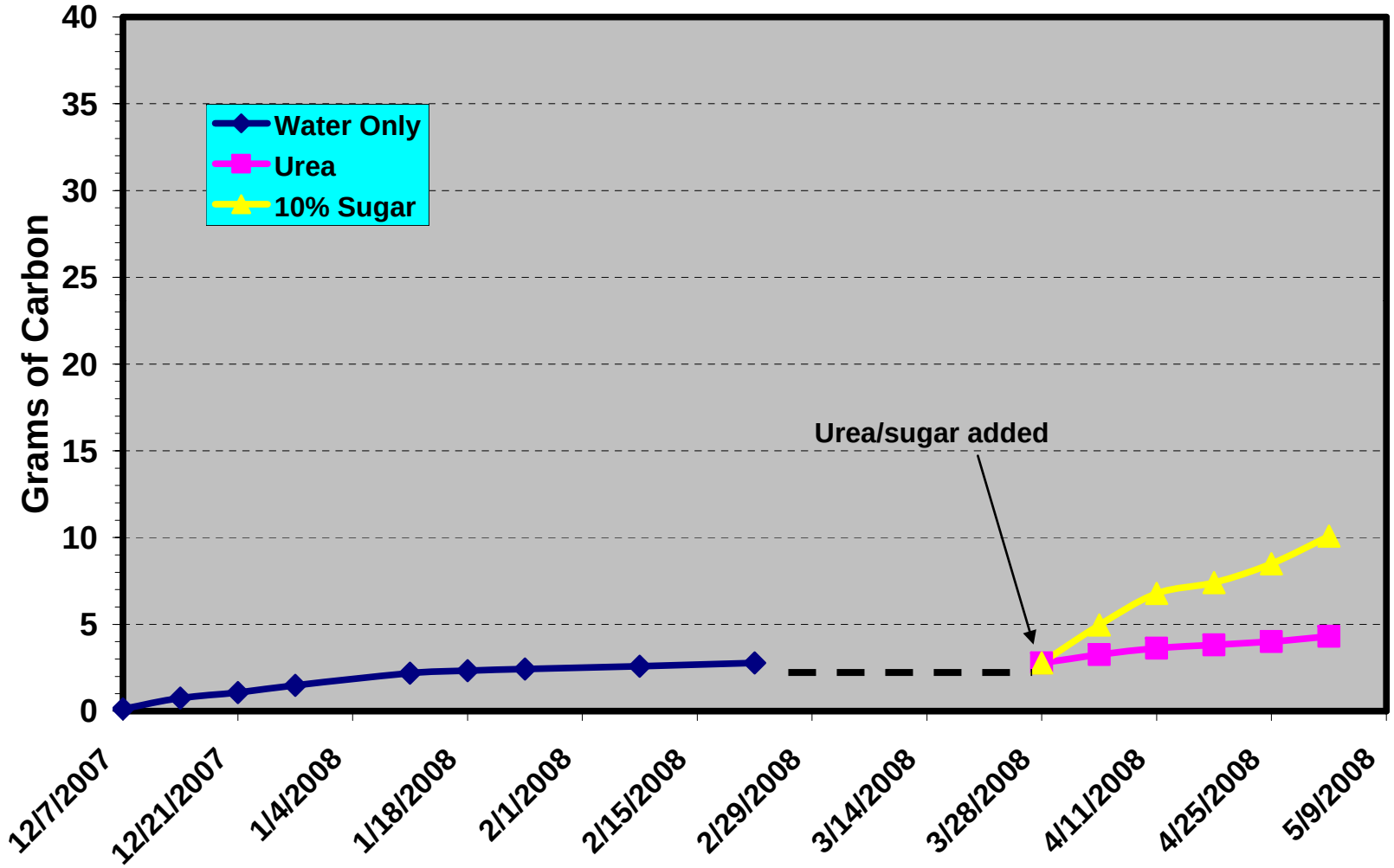



Cumulative Carbon Loss in Barnes Eroded Soil
Water Only
Urea
10% Sugar
Urea/sugar added
Grams of Carbon
0
5
10
15
20
25
30
35
40
12/7/2007
12/21/2007
1/4/2008
1/18/2008
2/1/2008
2/15/2008
2/29/2008
3/14/2008
3/28/2008
4/11/2008
4/25/2008
5/9/2008
Time (date)

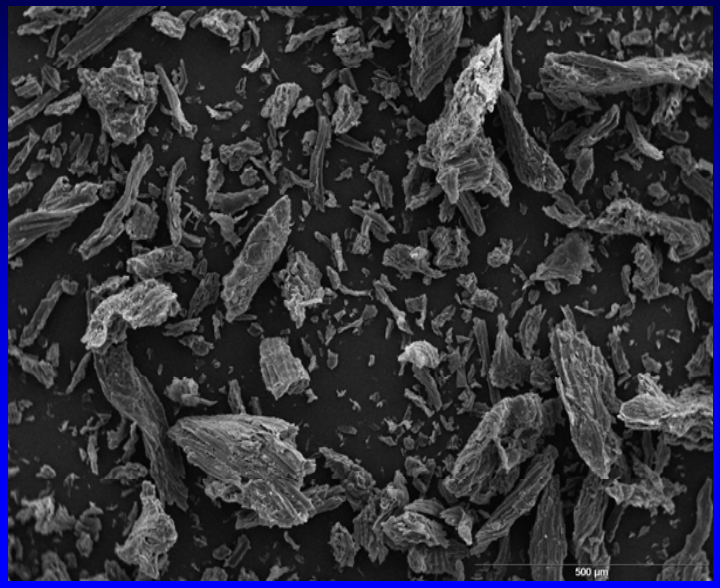
Cumulative Carbon Loss on Barnes Eroded/Turkey Manure Mix



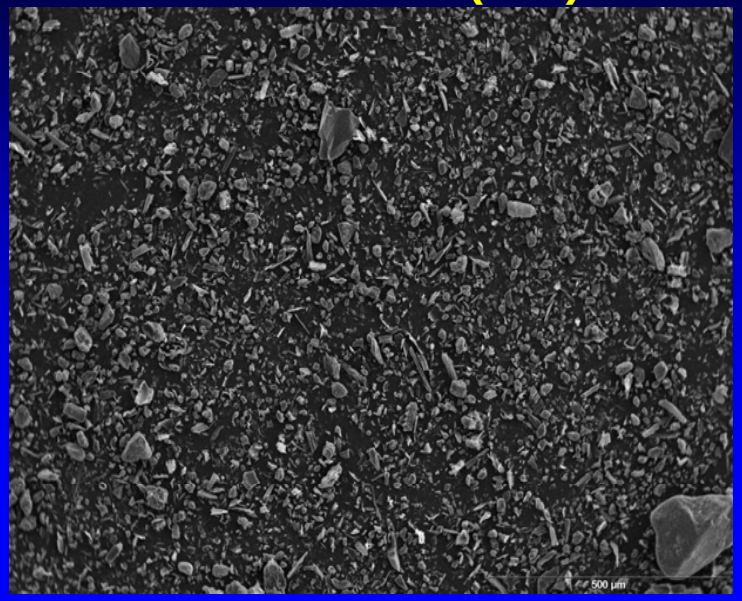
Cumulative Carbon Loss on Barnes Eroded/Australian Corn Char Mix



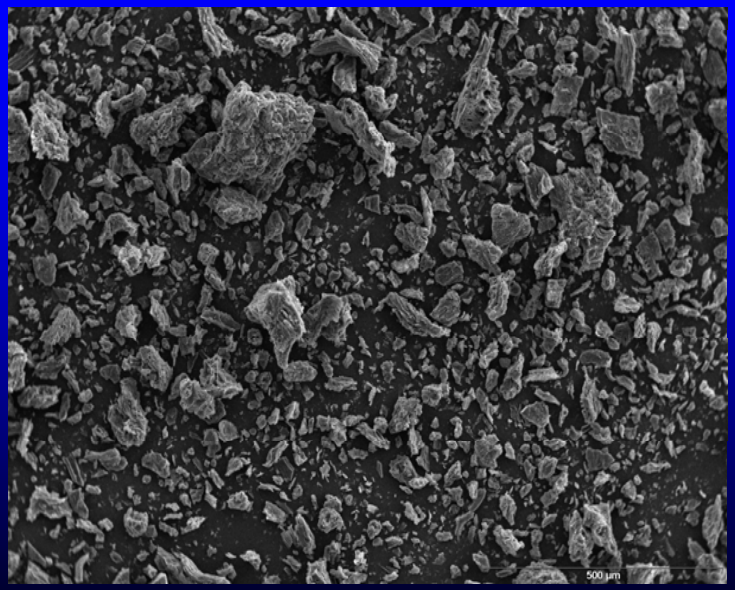
#2 Pine char (PC) – 500 um



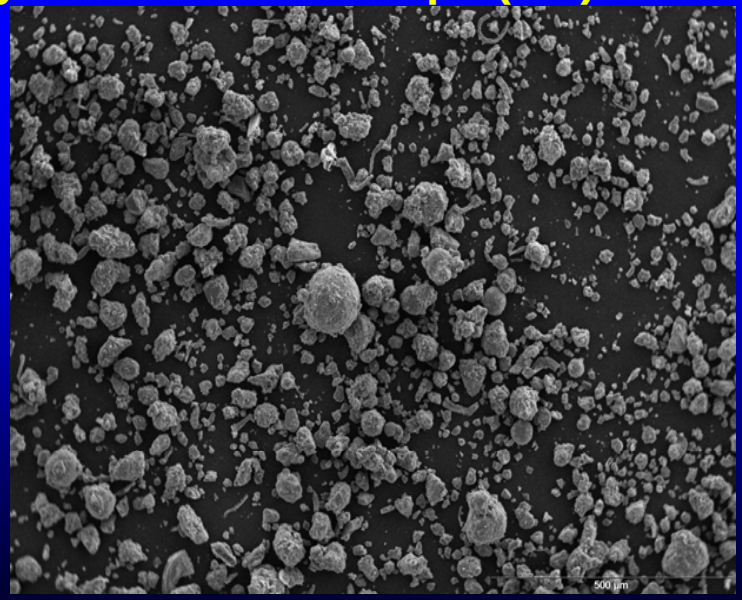
#4 IA corn stover char (ICC)– 500um



#3 Peanut Hull Char (PHC) – 500 um



#7 Turkey Manure/wood chips (TM) – 500 um



Summary

1. pH of raw char materials in H_2O ranged from 7.0 to 10.6

2. The addition of char increased pH of the soil-char mix over the soil alone and was soil dependant.

3. Cumulative CO_2 evolution was generally lowest in the pure char followed by the soil-char mix with the pure soil the highest.

4. The addition of sugar solution increased CO_2 evolution more than and urea solution.

5. The C:N ratio of char materials varied from 20 to 291.

6. The char nutrient concentration was very diverse depending on the feedstock composition and the combustion process with variable amounts of Al, Ca, Fe, K, Mg, Mn, P,S and Zn that may be of practical significance.