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[Outagamie County – City of Appleton Compost Pilot Project Final Report]

Final Report
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TABLE OF CONTENTS

1. INTRODUCTION

The Outagamie County – City of Appleton Compost Pilot Project has been in place since 2010 evaluating windrow composting Class B biosolids producing a Class A biosolids product per NR 204 and high quality compost meeting US Compost Council STA program specifications. The intent is to continue to evaluate and improve aspects of composting operations focusing on material research and performance demonstration in 2012.

This project is important in order to demonstrate large-scale application for an outdoor windrow composting operation at the Outagamie County Landfill (OCL). By evaluating several aspects of the compost and researching the performance of the windrows it is the ultimate goal to improve product quality and performance of the composting process.

1.1 Objectives

The specific objectives of the project were to evaluate physical, chemical, and biological parameters of compost. Material demonstration in erosion prevention and sediment control, nutrient loss and migration evaluation, plant vigor evaluation, and plant nutrient and metal uptake. These objectives were achieved through bench scale and pilot scale models. Research elements are delineated into four "Topics" as summarized below with further explanation found within the pertinent sections of this report.

- Topic 1: Evaluation of the Physical, Chemical, and Biological Parameters of Compost.
- Topic 2: Pilot Scale Material Demonstration. Usefulness of Biosolids Compost Material in Bank Stabilization Application.
- Topic 3: Nutrient Loss at a Laboratory Scale and Pilot Scale Model
- Topic 4: Plant Vigor Evaluation – Greenhouse and Field Study to Evaluate Soil Test, Nutrient and Metals Uptake, Pant Growth, Health, and Yield by Various Plant Species.

1.2 Approach

This project evaluates a compost material produced by the Outagamie County-City of Appleton Pilot Project for use in erosion prevention and sediment control, plant vigor utilizing different applications, and soil uptake response through bench and pilot-scale studies. The details of what is to be accomplished in each topic, the results and conclusions will follow in each section.

2. Evaluation of the Physical, Chemical, and Biological Parameters

2.1 Procedure

Physical parameters of the compost were evaluated to characterize the suitability of the material for application of a variety of purposes. The chemical parameters were evaluated to establish baseline nutrient and metal content of the compost and soil (garden plot) material. Nutrients were evaluated using an Analytical Automated Nutrient Analyzer (SEAL Analytical, ltd. Mequon, WI). Metals were evaluated using Inductively Coupled Plasma (ICP). Biological parameters were evaluated to identify fecal indicator organisms, pathogens, and microbial inhibition. Total coliforms and *Escherichia co*li (*E. coli*) were analyzed every week from the leachate of various tests. *E. coli* is traditionally used as a fecal indicator bacterium to determine the possible presence of fecal contamination and to estimate the amount of contamination in water, foods, and other samples. The detection of indicator bacteria is preferred over direct pathogen detection because the former are considered to be normal, non-pathogenic intestinal inhabitants that are present in feces and wastewater and because they are technically easier to detect and quantify than pathogens. The most widely used indicator bacteria are the so-called total and fecal coliforms. The term "coliform" has been used to describe various genera of the family *Enterobacteriaceae* that ferment lactose and *Escherichia* is one of the genus of that family.

The physical (A-C), chemical (D and E) and biological parameters (F and G) measured included:

A. Particle size determination to assess particle size using a mechanical sieve field analysis kit (Geotech Environmental Equipment Inc.)
B. Water holding capacity was determine using standard method (SM 03.10-E). It is the percent of the total volume of the medium that is filled with water after irrigation and drainage.
C. Dry weight (TS), Organic dry weight (oTS), and bulk density.
    a. Dry weights (TS): Analyzed using the DIN:EN12880
    b. Organic dry weight (oTS): Analyzed using the DIN:EN12879
    c. Bulk density: Analyzed based on the TMECC 03.03
D. Nutrient analysis
    a. Calcium (Ca)
    b. Magnesium (Mg)
    c. Total Nitrogen (TN)
    d. Potassium (K)
    e. Phosphorus (P)
E. Metal analysis
    a. Arsenic (As)
    b. Cadmium (Cd)
    c. Chromium (Cr)
    d. Copper (Cu)
    e. Mercury (Hg)
    f. Lead (Pb)
F. Total coliforms/*E. coli* (Most Probable Number: MPN/g): Quantify Total coliforms and *E. coli* using SM 9223

G. Pathogen testing
   a. *Salmonella*: Identify and quantified using culture techniques. (EPA Method 1682)
   b. *Campylobacter*: Identify and quantified using culture techniques. (Oyarzabal et al. 2005)

2.2 Results and Discussion

The compost can provide essential nutrients for plant growth and can be a cofactor for several important enzyme activates. Nutrients such as calcium are an essential part of plant cell wall structure and must be present for the formation of new cells. The nutrients identified as macronutrients are required in greater quantities and micronutrients are required in small to trace quantities (TMECC 04.05). The macronutrients are further classified as primary and secondary nutrients; total nitrogen (N), phosphorus (P) and potassium (K) are the three primary nutrients. The secondary nutrients are magnesium (Mg) and calcium (Ca).

Metals such as arsenic (As), cadmium (Cd), copper (Cu), lead (Pb) and mercury (Hg) were also analyzed. These are potential environmental pollutants at certain concentrations and can be of concern with finished compost uses. For example, cadmium is toxic to animals and humans at levels not toxic to plants because it inhibits calcium uptake in bones. Mercury inhibits respiration at concentrations greater than 100 mg kg^{-1} dw (TMECC 04.06).

The compost was also analyzed for pathogenic organisms because it's derived from human or animal wastes. If the compost does not achieve the thermophilic conditions throughout the composting mass, some pathogenic microbes could survive. Thus, the compost that is used or distributed to the general public must comply with local and state limits.

The evaluation of the compost and soil helped characterize the suitability of the material for applications of variety of purposes. The analysis helped determine the overall composition of the compost material and its overarching benefits to the soil.

The physical, chemical and biological comparison between the compost material and soil had varying differences. The nutrient levels (N, P, K, Mg and Ca) in the compost (screened and unscreened) were 2-10 times higher in comparison to the soil (Tables 2.1-2.3). These results were comparable to the 2 windrow composite laboratory test results provided by the City of Appleton compost pilot project. The increased nutrient levels could have benefits on plant health and growth over a longer term. Large differences in growth of plants grown in soil and compost amended soil were observed in our plant vigor analysis (Section 5).

The results for metals analysis were all fairly similar in compost and the soil material (Table 2.1-2.3). The results were below the Wisconsin DNR NR 502.12(16) and US Composting Council (USCC) general ranges. NR 502.12(16) is the Wisconsin administration code, which regulates standards for high quality compost, known as Class A compost. Class A compost meets an established state standard for stability and maturity, metals, contaminants and pathogens. The pathogenic organisms *E. coli*, *Campylobacter* and *Salmonella* were not detected within either of the samples. The coliform bacteria detected were below the NR 502.12(16) and USCC general range.

Laboratory analysis indicates that the compost contains beneficial nutrient levels that contribute to plant health and growth. In comparison to the soil alone it provides a greater abundance of the needed macronutrients for the plants. The data analyzed for the City of Appleton compost material had relatively low levels of metals and the pathogenic organisms were not detected.

Table 2.1: Physical, chemical and biological analysis of the plot soil provided at the Brewster street garden plot.

Sample Description	Parameter	Units	Result	USCC (General Range)
Plot Soil	pH	-	7.2	6 - 8.5
Plot Soil	Dry matter	%	72.703	40 - 75
Plot Soil	Organic dry matter	%	21.799	> 30
Plot Soil	Bulk density	kg/m^3	1,135.91	NA
Plot Soil	Particle Size	inches	0.0746	NA
Plot Soil	Water Holding Capacity	% ww^{-1} dw	0.4123	NA
Plot Soil	Total Nitrogen, total kjeldahl as N on solids	mg/Kg WWB	1,600	NA
Plot Soil	Phosphorus, total recoverable as P by ICP	mg/Kg WWB	320	NA
Plot Soil	Potassium, total recoverable as K by ICP	mg/Kg WWB	580	NA
Plot Soil	Magnesium, total recoverable as Mg by ICP	mg/Kg WWB	11,000	NA
Plot Soil	Calcium, total recoverable as Ca by ICP	mg/Kg WWB	17,000	NA
Plot Soil	Arsenic, total recoverable as As by ICP	mg/Kg WWB	2.1	< 41
Plot Soil	Cadmium, total recoverable as Cd by ICP	mg/Kg WWB	0.13	< 39
Plot Soil	Chromium, total recoverable as Cr by ICP	mg/Kg WWB	7.9	NA
Plot Soil	Copper, total recoverable as Cu by ICP	mg/Kg WWB	6	< 1,500
Plot Soil	Mercury, total as Hg on solids	mg/Kg WWB	ND	< 17
Plot Soil	Lead, total recoverable as Pb by ICP	mg/Kg WWB	20	< 300
Plot Soil	Coliform bacteria	MPN/g	146.2	< 1,000
Plot Soil	*E. coli*	MPN/g	<1	NA
Plot Soil	*Campylobacter*	CFU/g	ND	NA
Plot Soil	*Salmonella*	CFU/g	ND	< 3 MPN $(4 .g)^{-1}$

Table 2.2: Physical, chemical and biological analysis of the unscreened compost material.

Sample Description	Parameter	Units	Result	NR502 (mg/Kg DWB)	USCC (General Range)
Unscreened Compost	pH	-	7.3	NA	6 - 8.5
Unscreened Compost	Dry matter	%	73.974	NA	40 - 75
Unscreened Compost	Organic dry matter	%	19.155	NA	> 30
Unscreened Compost	Bulk density	kg/m^3	811.95	NA	NA
Unscreened Compost	Particle Size	inches	0.1064	NA	NA
Unscreened Compost	Water Holding Capacity	$\% \ ww^{-1} \ dw$	0.5568	NA	NA
Unscreened Compost	Total Nitrogen, total kjeldahl as N on solids	mg/Kg WWB	3,900	NA	NA
Unscreened Compost	Phosphorus, total recoverable as P by ICP	mg/Kg WWB	2,800	NA	NA
Unscreened Compost	Potassium, total recoverable as K by ICP	mg/Kg WWB	1,700	NA	NA
Unscreened Compost	Magnesium, total recoverable as Mg by ICP	mg/Kg WWB	24,000	NA	NA
Unscreened Compost	Calcium, total recoverable as Ca by ICP	mg/Kg WWB	91,000	NA	NA
Unscreened Compost	Arsenic, total recoverable as As by ICP	mg/Kg WWB	1.5	12	< 41
Unscreened Compost	Cadmium, total recoverable as Cd by ICP	mg/Kg WWB	[0.14]	6.1	< 39
Unscreened Compost	Chromium, total recoverable as Cr by ICP	mg/Kg WWB	6.4	120	NA
Unscreened Compost	Copper, total recoverable as Cu by ICP	mg/Kg WWB	24	400	< 1,500
Unscreened Compost	Mercury, total as Hg on solids	mg/Kg WWB	[0.050]	1.2	< 17
Unscreened Compost	Lead, total recoverable as Pb by ICP	mg/Kg WWB	6.8	95	< 300
Unscreened Compost	Coliform bacteria	MPN/g	308	1,000	< 1,000
Unscreened Compost	*E. coli*	MPN/g	<1	NA	NA
Unscreened Compost	Campylobacter	CFU/g	ND	NA	NA
Unscreened Compost	*Salmonella*	CFU/g	ND	$3 \ MPN \ (4 \ .g)^{-1}$	$< 3 \ MPN \ (4 \ .g)^{-1}$

Table 2.3: Physical, chemical and biological analysis of the screened compost material.

Sample Description	Parameter	Units	Result	NR502 (mg/Kg DWB)	USCC (General Range)
Screened Compost	pH	-	7.1	NA	6 - 8.5
Screened Compost	Dry matter	%	78.981	NA	40 - 75
Screened Compost	Organic dry matter	%	5.691	NA	> 30
Screened Compost	Bulk density	kg/m^3	755.97	NA	NA
Screened Compost	Particle Size	inches	0.0855	NA	NA
Screened Compost	Total Nitrogen, total kjeldahl as N on solids	mg/Kg WWB	5,800	NA	NA
Screened Compost	Phosphorus, total recoverable as P by ICP	mg/Kg WWB	3,500	NA	NA
Screened Compost	Potassium, total recoverable as K by ICP	mg/Kg WWB	2,000	NA	NA
Screened Compost	Magnesium, total recoverable as Mg by ICP	mg/Kg WWB	16,000	NA	NA
Screened Compost	Calcium, total recoverable as Ca by ICP	mg/Kg WWB	82,000	NA	NA
Screened Compost	Arsenic, total recoverable as As by ICP	mg/Kg WWB	[1.2]	12	< 41
Screened Compost	Cadmium, total recoverable as Cd by ICP	mg/Kg WWB	0.23	6.1	< 39
Screened Compost	Chromium, total recoverable as Cr by ICP	mg/Kg WWB	5.8	120	NA
Screened Compost	Copper, total recoverable as Cu by ICP	mg/Kg WWB	28	400	< 1,500
Screened Compost	Mercury, total as Hg on solids	mg/Kg WWB	[0.041]	1.2	< 17
Screened Compost	Lead, total recoverable as Pb by ICP	mg/Kg WWB	5.7	95	< 300
Screened Compost	Coliform bacteria	MPN/g	967.8	1,000	< 1,000
Screened Compost	*E. coli*	MPN/g	<1	NA	NA
Screened Compost	Campylobacter	CFU/g	ND	NA	NA
Screened Compost	*Salmonella*	CFU/g	ND	3 MPN $(4\ .g)^{-1}$	< 3 MPN $(4\ .g)^{-1}$

2.3 Conclusions

- The nutrient levels (N, P, K, Mg and Ca) in the compost (screened and unscreened) were 2-10 times higher in comparison to the garden plot soil.
- The results for heavy metals and hazardous elements analysis were below the US Composting Council (USCC) general ranges.
- The pathogenic organisms *E. coli*, *Campylobacter* and *Salmonella* were not detected.
- The coliform bacteria detected were below the USCC general range.

3. Pilot Scale Material Demonstration

3.1 Procedure

A pilot scale bank located at the OCL was proposed for use by the City of Appleton and provided by the OCL for the purpose of the study. The bank was approximately 100 feet in width and 110 feet in length with a 4:1 slope (Figure 3.1). The site was utilized to demonstrate bank stabilization, to assess biological loss and nutrient loss over time or in effect with rain. The analysis of grass growth over time at each plot was also assessed. A total of six unique plots were utilized for the study (Figure 3.2).

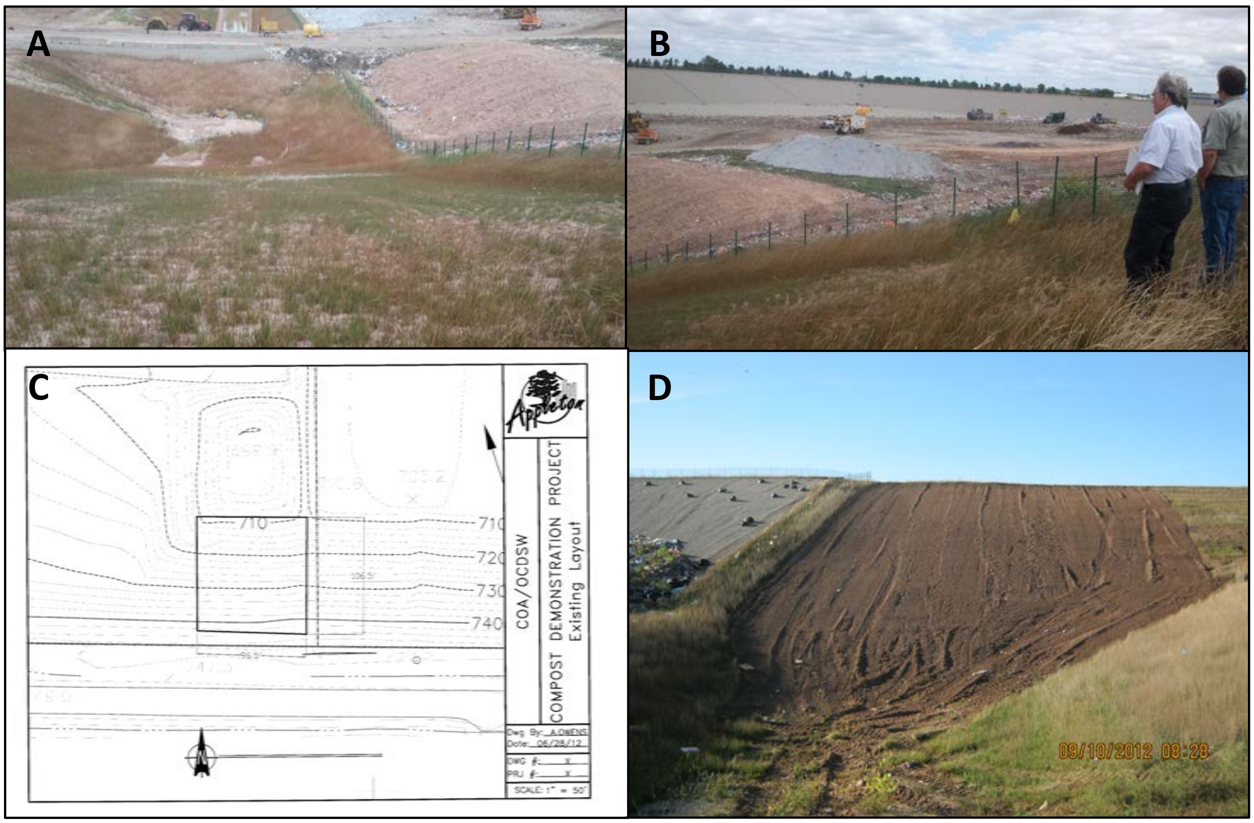


Figure 3.1: Outagamie County Landfill Site **A)** Site photo from top of slope before any site preparation occurred **B)** Side profile of 4:1 slope prior to any site preparation **C)** Elevation profile **D)** OCL site after preparation and before set up of the plots

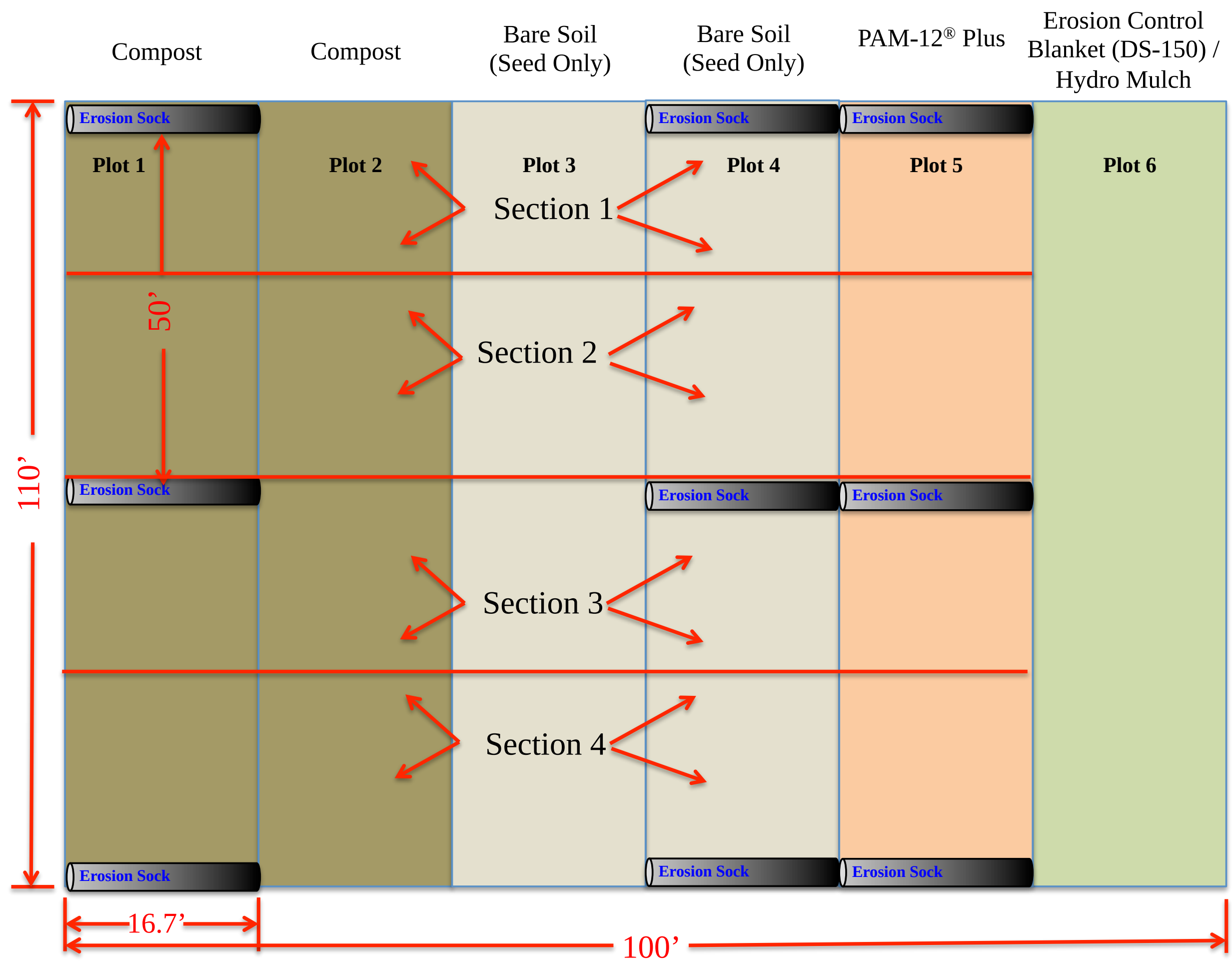


Figure 3.2: The erosion plot layout at the Appleton landfill plot.

A. Erosion prevention demonstration
   a. Bank stabilization (Figure 3.2 for plot layout)
      1. Compost material was utilized for the first two plots (Figure 3.3)
         i. Plot one: Blown compost was applied approximately two inches thick to the plot with the use of a pneumatic blower truck. The seed mix was added to the blown compost. One erosion sock was added to the plot every 50 feet. A total of three erosion socks were added; starting at the top of the hill.
         ii. Plot two: Same as plot one except no erosion socks were utilized.
         iii. Seed Mixture: General #30 Seed Mixture from Highway Department. Mixture composed of 30% Annual Ryegrass, 24% Red Fescue, 19% Kentucky Bluegrass, 14% Buccaneer Perennial Ryegrass, 13% Kenblue Kentucky Bluegrass.
      2. Bare soil plots
         i. Plot three: Plot was utilized as it was provided. Grass seed mix was applied via a broad cast spreader.
         ii. Plot four: Same as plot three except erosion socks were added to the plot every 50 feet. A total of three erosion socks were added.

3. PAM-12 Plus (Figure 3.4)
    i. Plot five: PAM-12 Plus, supplied by ENCAP, was applied to this plot. The material was sprayed onto the plot with the use of the pump trailer. Erosion socks were added in similar manner as plot one and four.
4. Erosion Control Blanket (DS-150)/ Hydro Mulch (Figure 3.5)
    i. Plot six: The Highway Department applied hydro mulch followed by erosion control blanket which represents a typical industry standard currently utilized in the county.
    ii. Only visual observations were conducted on this plot because of the overlaying erosion mat.

Figure 3.3: Preparation of plot one and two. **A)** Pneumatic blower truck used for application of compost material **B)** Application of blown compost **C)** View between plots two and three **D)** View of plots one and two after application of blown compost

Figure 3.4: Preparation of plot five. **A)** Hydro seeder was used to apply the PAM-12 Plus product **B)** Application of product onto plot **C)** close up of dry PAM-12 Plus **D)** After final application of product

Figure 3.5: Preparation of plot six. **A)** Hydro seeder was used to apply the hydro mulch product (DS-150) **B)** Spraying of product onto plot **C)** Final application of hydro mulch **D)** Application of final straw matting

b. Utilization of erosion socks (Figure 3.6)

1. The sock material utilized for the study was the 12 inch DuraSoxx HD product purchased from Filtrexx International.
2. The erosion socks were filled with mulch supplied by the City of Appleton.
3. Plot with and without erosion socks (Figure 3.2).
    i. With erosion socks (plots one, four and five)
    ii. Without erosion socks (plots two and three)
4. Monitoring the physical erosion of the banks.
5. Assessment of nutrient and biological loss over time

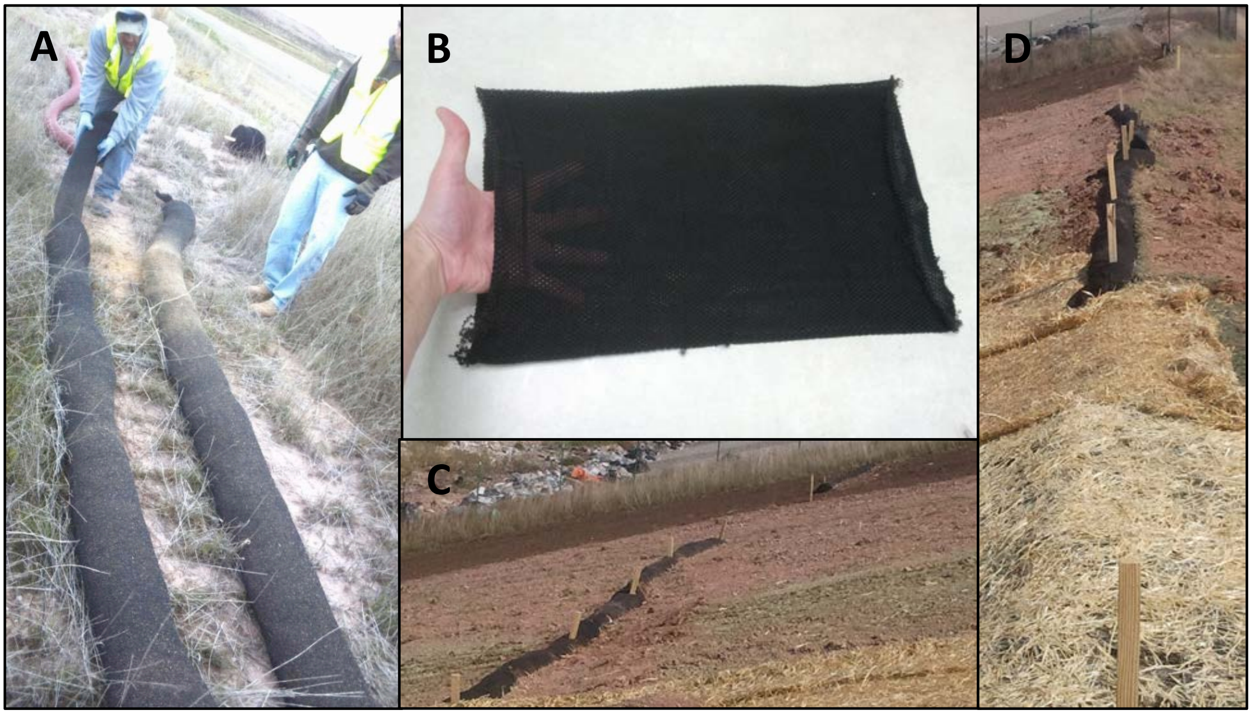


Figure 3.6: Erosion Sock Preparation and Placement. **A)** Filling of erosion socks with blower truck **B)** Erosion sock material used was the 12 inch diameter DuraSoxx HD from Filtrexx International **C)** Example of final placement of erosion sock at 50 feet **D)** Example of final placement of erosion sock at top of slope

B. Assessment of nutrient and biological loss over time.

The assessment of nutrient, biological loss and physical erosion over time was conducted in the same manner for bank stabilization plots and erosion sock plots.

a. Nutrient movement

1. Evaluation of the nutrient content was done prior to the start of the study and once per week during the study.
2. Samples were collected from three sections within each of the plot (Figure 3.2). Cases of a rain event, the samples were also collected from a fourth section further below the hill. Each week samples were collected from different locations within the same section (sections one, two, and three). A plastic flag was placed in a spot where the sample was collected each week.
3. Nutrients include:
    i. Total Nitrogen (N)
    ii. Total Phosphorus (P)
    iii. Potassium (K)
    iv. Magnesium (Mg)
    v. Calcium (Ca)

b. Pathogen movement

1. Evaluation of the pathogen movement prior to the start of the study and once a week during the study.
2. Pathogens include:
    i. Total coliforms / *E. coli* (Most Probable Number: MPN/g)
    ii. *Salmonella* (Colony Forming Units per gram: CFU/g)
    iii. *Campylobacter* (Colony Forming Units per gram: CFU/g)

c. Physical erosion (Figure 3.7)

1. Erosion movement was monitored from the first five plots.
2. Evaluation of sediment movement prior to the start of the study and once a week during the study. The erosion movement was monitored for a total of eight weeks.
3. The physical erosion was monitored by measuring the amount of increased or decreased sediment material around the mounted stakes.
    i. The stakes were marked with a reference point before the start of this phase.
    ii. The amount of increase or decrease of sediment around the stake was measured (Amount of erosion (cm)).

Figure 3.7: Physical erosion movement evaluation at the City of Appleton landfill plot. The original line on the stake was marked in the beginning phase of the study. The erosion was monitored once a week for eight weeks total. **A)** Plot two and **B)** Plot five example

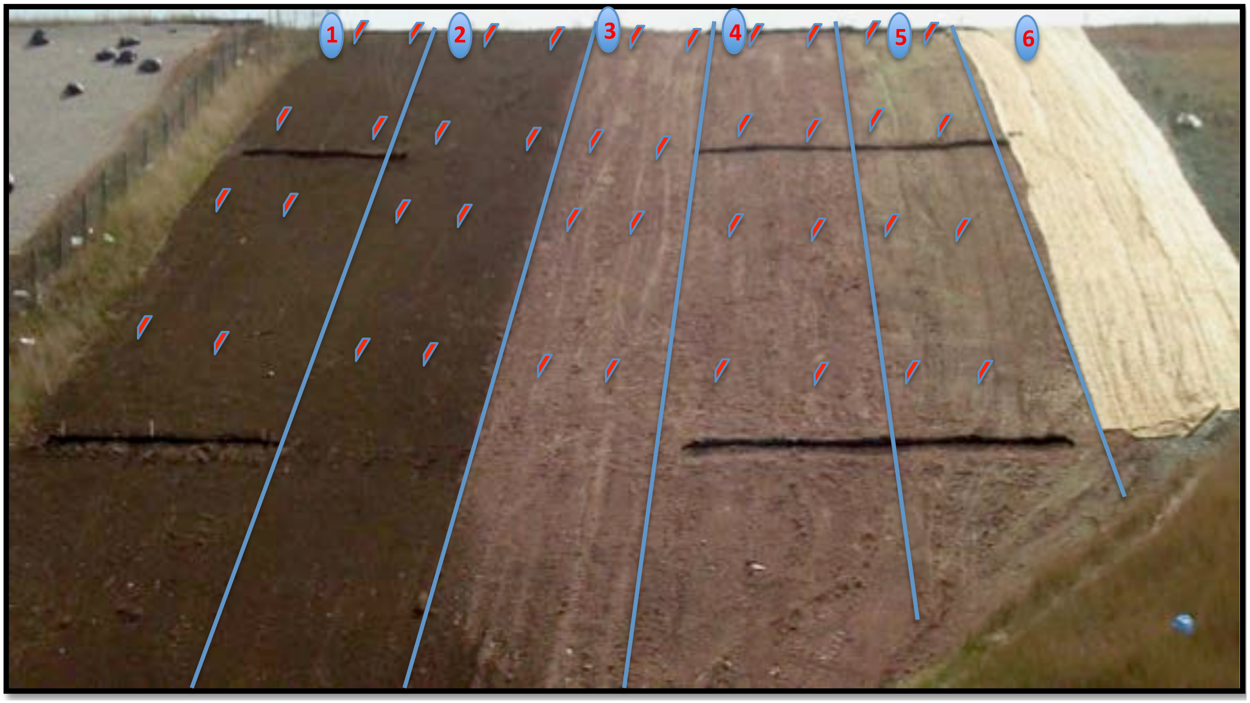


Figure 3.8: Finished erosion plot layout at the City of Appleton landfill site. Red dashes represent the placement of the wooden stakes used for the evaluation of erosion movement.

3.2 Results and Discussion

Healthy soil is an important factor in protecting our waters by increasing the soil's ability to retain water and decreases runoff. Stormwater runoff pollutes water by carrying soil, fertilizers and pesticides to nearby streams (Wang *et al*. 2009). Compost can encourage healthy root systems that help decrease water runoff. In some cases compost can help lower chemical pesticides since it contains beneficial microorganisms that help protect plants from diseases and pests (Wang *et al*. 2009). Compost can also help bind clusters of soil particles; this can provide a good soil structure. A good soil structure is beneficial because it is full of tiny air channels and pores that hold air, moisture and nutrients (Wang *et al*. 2009). In similar fashion, compost helps sandy soil retain water and nutrients, loosens tightly bound particles in clay or silt soil so roots can spread, water drain and air penetrate. Compost can hold nutrients tight enough to prevent them from washing out, and loose enough so plants can take them up as needed.

3.2.1 Visual Observations of Grass Growth

The erosion control study and the visual observations of grass growth were completed between September and November 2012. Within the first two weeks of the study, minimal grass growth was observed in all six of the plots. However, within a month into the study (see Figure 3.9 – 10/23/2012), a noticeable difference in grass growth was observed. Plots one and two (compost) had increased grass growth in comparison to plots three, four and five. Within the eight week erosion plot study, it only rained within the weeks of 10/10 to 10/16 (total rain intensity = 0.7366 cm) and between the week of 10/17 to 10/23/2012 (total rain intensity = 1.1938 cm). The majority of this rainfall was on the days of 10/13 (0.508 cm) and 10/17/2012 (0.889). The first total rainfall had a higher impact on the compost plots than bare soil plots. Following the second rainfall, higher grass growth was observed in all six of the plots (see Figure 3.10 – 11/06/2012). At this point in the study, compost plots had increased grass coverage in comparison to plots three, four, and five. The rainfall had also created water channels within plots two, four and five (Figure 3.11).

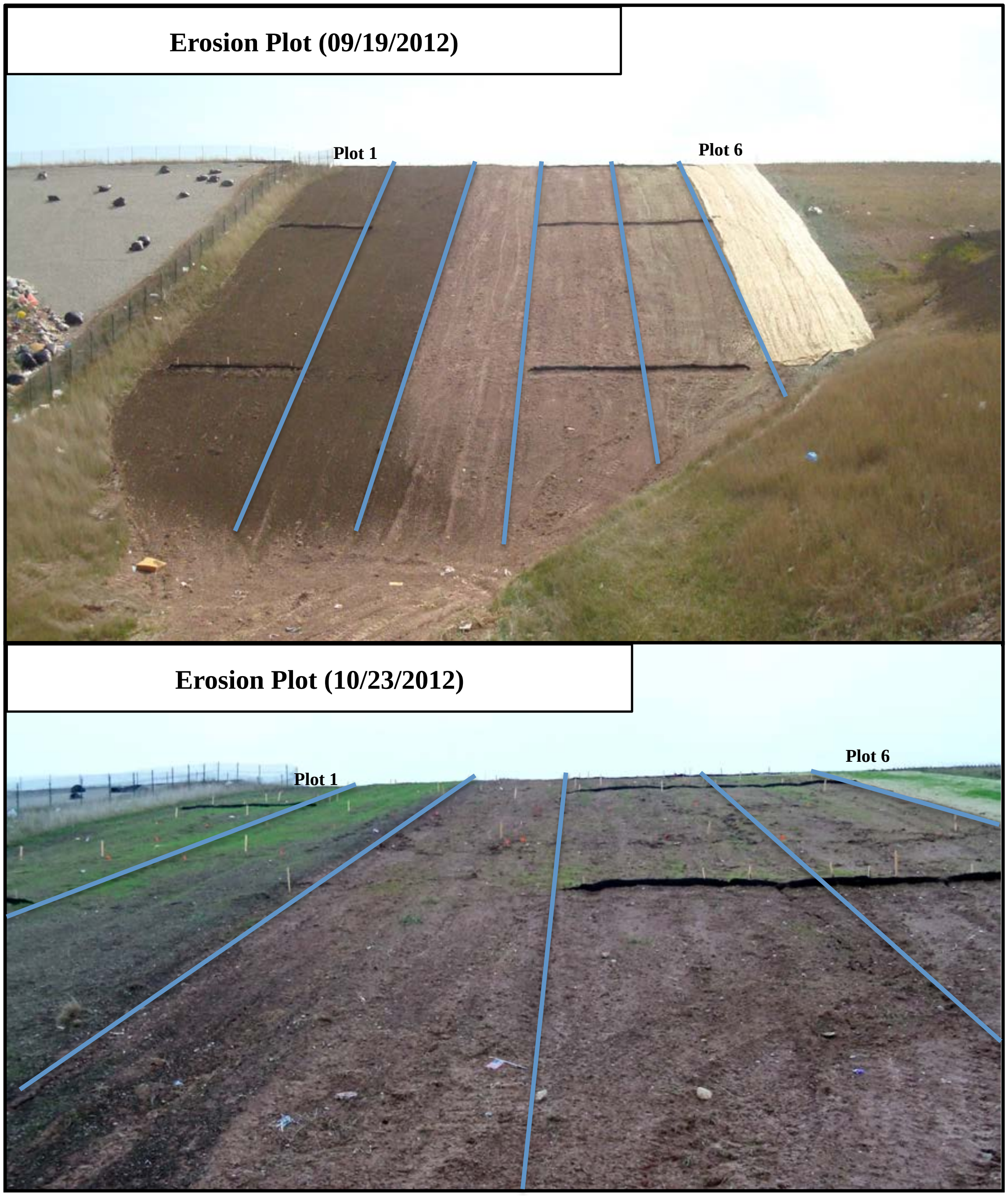


Figure 3.9: Visual observations of grass growth from erosion plot study five weeks after plot establishment. Plots are arranged from left to right (plot 1 – plot 6), see Figures 3.2 and 3.8 for additional details on the plot layout.

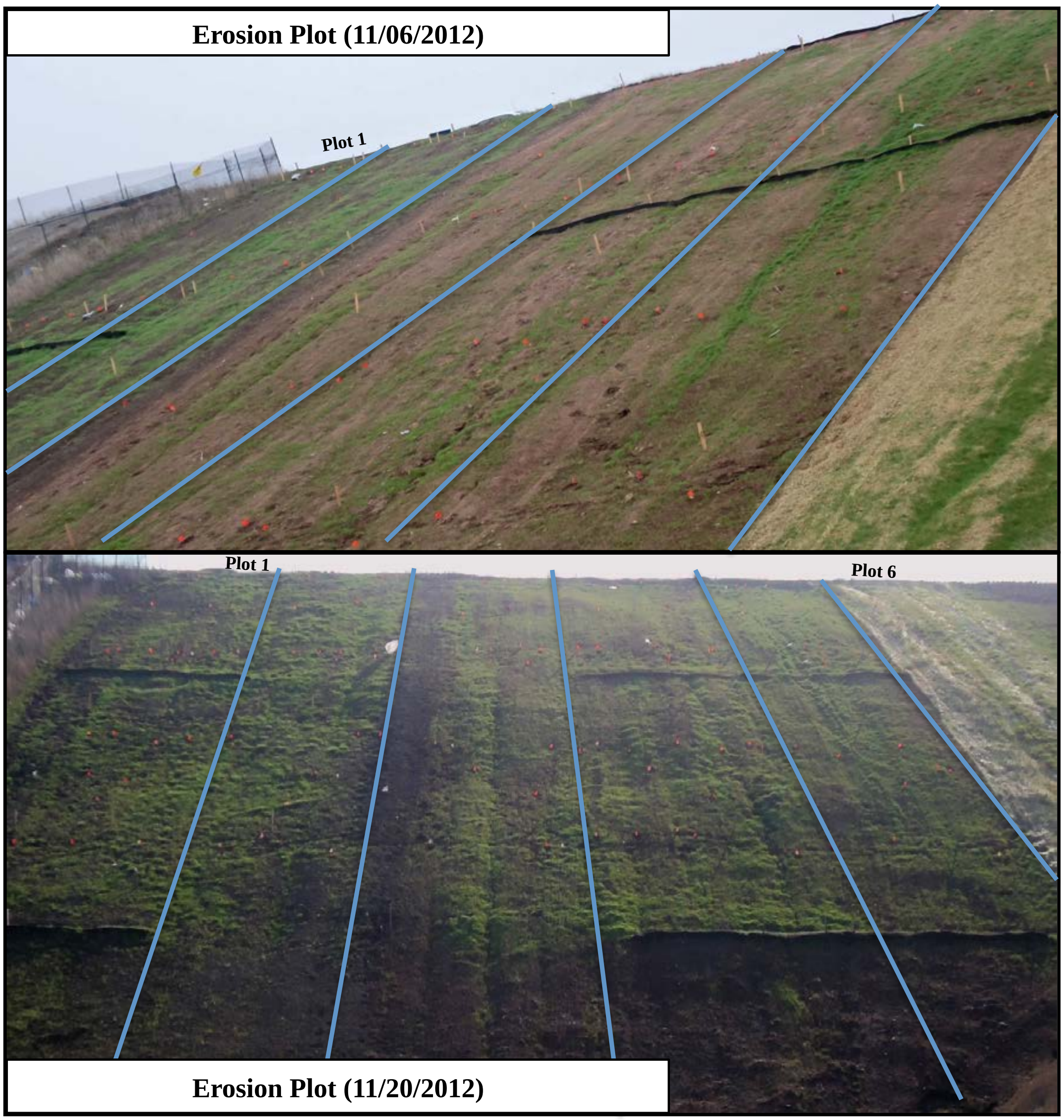


Figure 3.10: Visual observations of grass growth from erosion plot study on 11/06/12 and 11/20/12. The plot was analyzed for a total of eight weeks. Plots are arranged from left to right (plot 1 – plot 6), see Figures 3.2 and 3.8 for additional details on the plot layout.

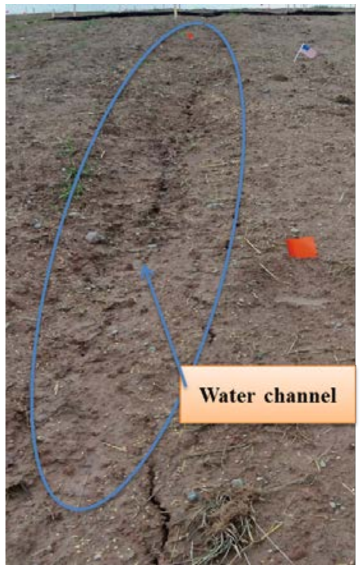


Figure 3.11: An example of water channel formation (10-19-2012) within plot four (Bare soil + erosion socks)

3.2.2 Nutrient Movement

Analysis of nutrients (Ca, Mg, N, K, and P) was conducted over an eight week period of time from sections one through four of plots one through five. Figures 3.12 – 3.16 summarizes the averages for each nutrient over the eight weeks. The detailed tables and individual results are located in Appendix 7.2.

Average calcium levels from the compost plots were approximately twice that found from the non-compost plots (101,656 mg/Kg vs. 49,000 mg/Kg). Only slight differences in calcium were observed between individual sections within a plot. Magnesium levels ranged from 21,500 mg/Kg to 27,875 mg/Kg with an overall average level of 24,262.5 mg/Kg across all plots. Little variation in overall magnesium was observed between plots or sections within plots. Average nitrogen levels from the compost plots were approximately nine times higher than non-compost plots (5,829 mg/Kg vs. 624 mg/Kg), but relatively little variation between sections within each plot was observed. Average potassium levels from the compost plots were approximately two times lower than non-compost plots (1,539 mg/Kg vs. 3,336 mg/Kg). Again relatively little variation was observed between sections within each plot. Generally speaking phosphorous was shown to be relatively consistent between all plots, however there was one data point in particular that appears to be an outlier (bare soil plot three section 4 O-P 1,107 mg/Kg). The overall average phosphorous level was 244 mg/Kg when averaging the data across all sections and all plots (203 mg/Kg compost plots and 272 mg/Kg from non-compost plots).

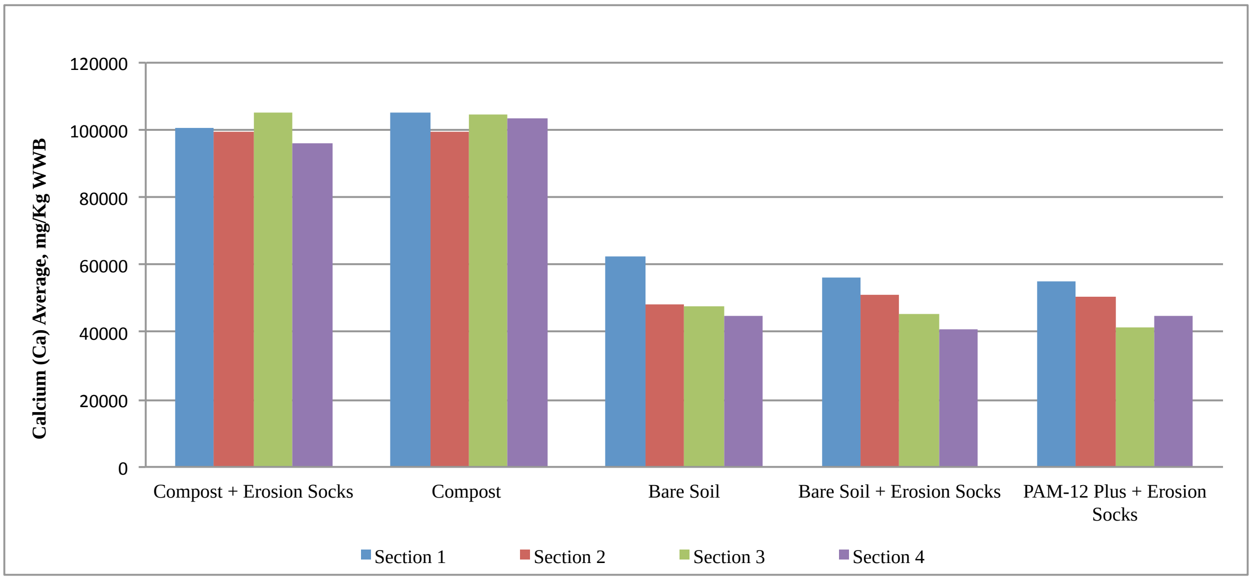


Figure 3.12: Average amount of calcium overtime (eight weeks) within plot one (compost + erosion socks), plot two (compost), plot three (bare soil), plot four (bare soil + erosion socks), and plot five (End Cap PAM-12 + erosion socks). The data represents the average calcium (mg/Kg) for an eight week period.

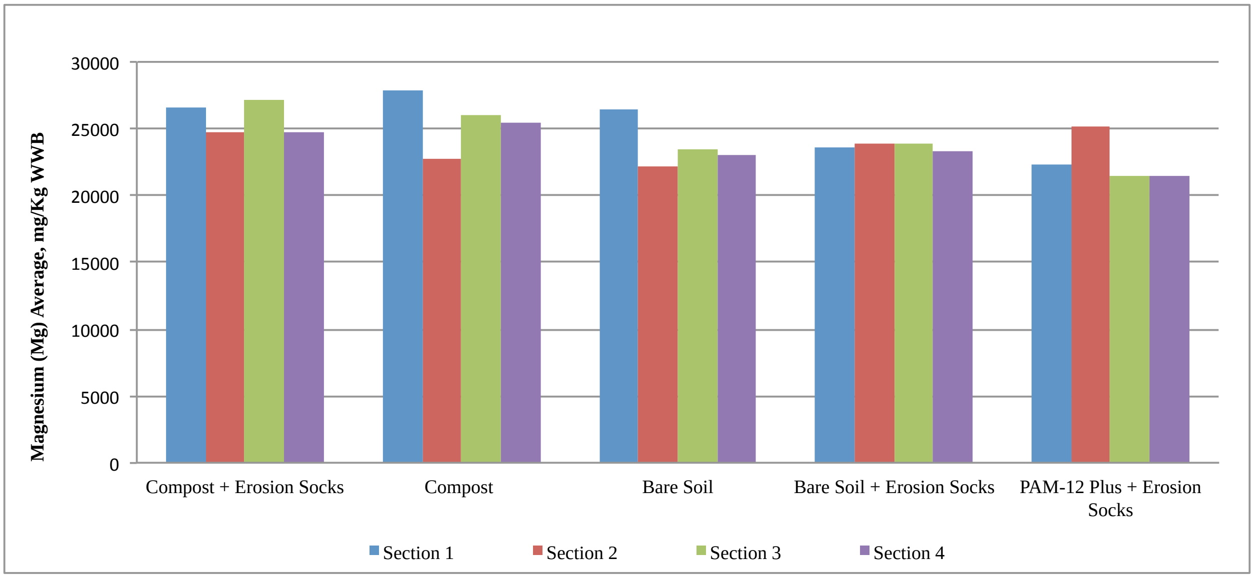


Figure 3.13: Average amount of magnesium overtime (eight weeks) within plot one (compost + erosion socks), plot two (compost), plot three (bare soil), plot four (bare soil + erosion socks), and plot five (PAM-12 Plus + erosion socks). The data represents the average magnesium (mg/Kg) for an eight week period.

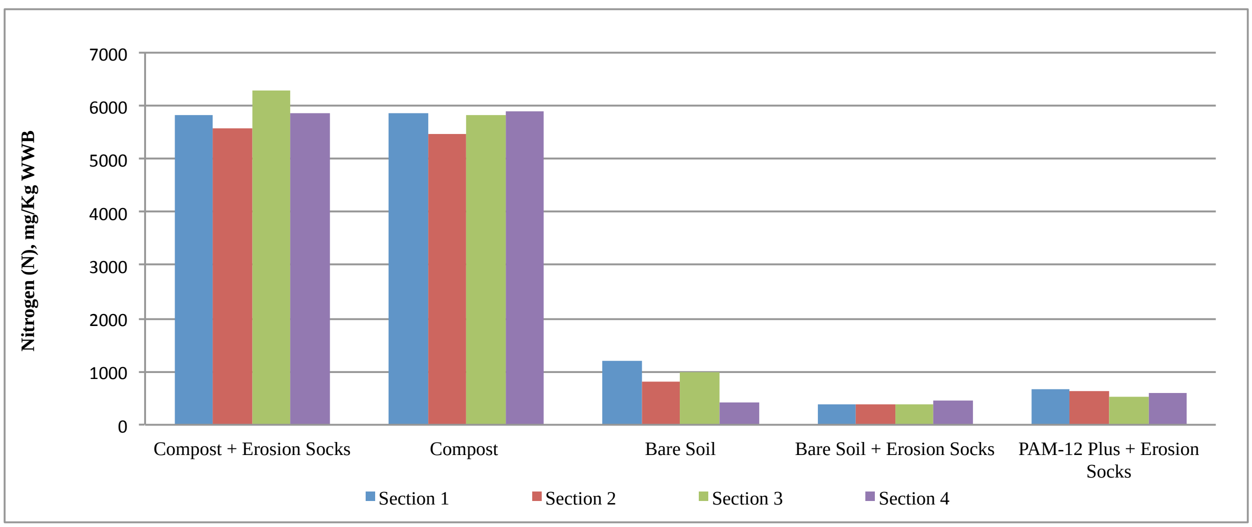


Figure 3.14: Average amount of nitrogen overtime (eight weeks) within plot one (compost + erosion socks), plot two (compost), plot three (bare soil), plot four (bare Soil + erosion socks), and plot five (PAM-12 Plus + erosion socks). The data represents the average nitrogen (mg/Kg) for an eight week period.

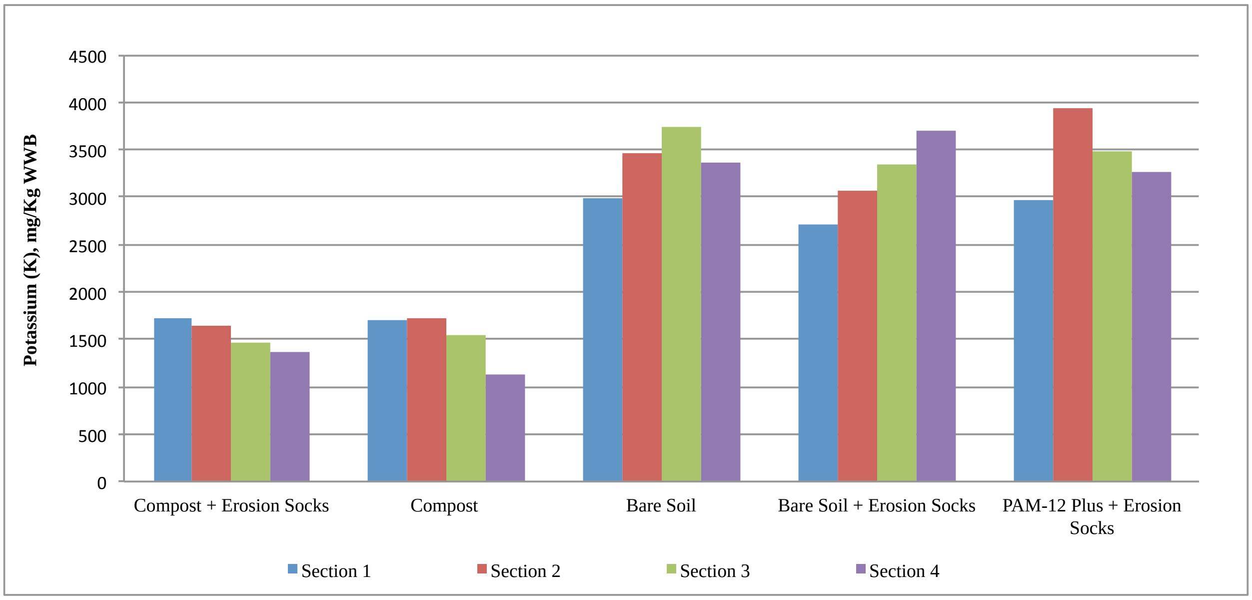


Figure 3.15: Average amount of potassium overtime (eight weeks) within plot one (compost + erosion socks), plot two (compost), plot three (bare soil), plot four (bare soil + erosion socks), and plot five (PAM-12 Plus + erosion socks). The data represents the average potassium (mg/Kg) for an eight week period.

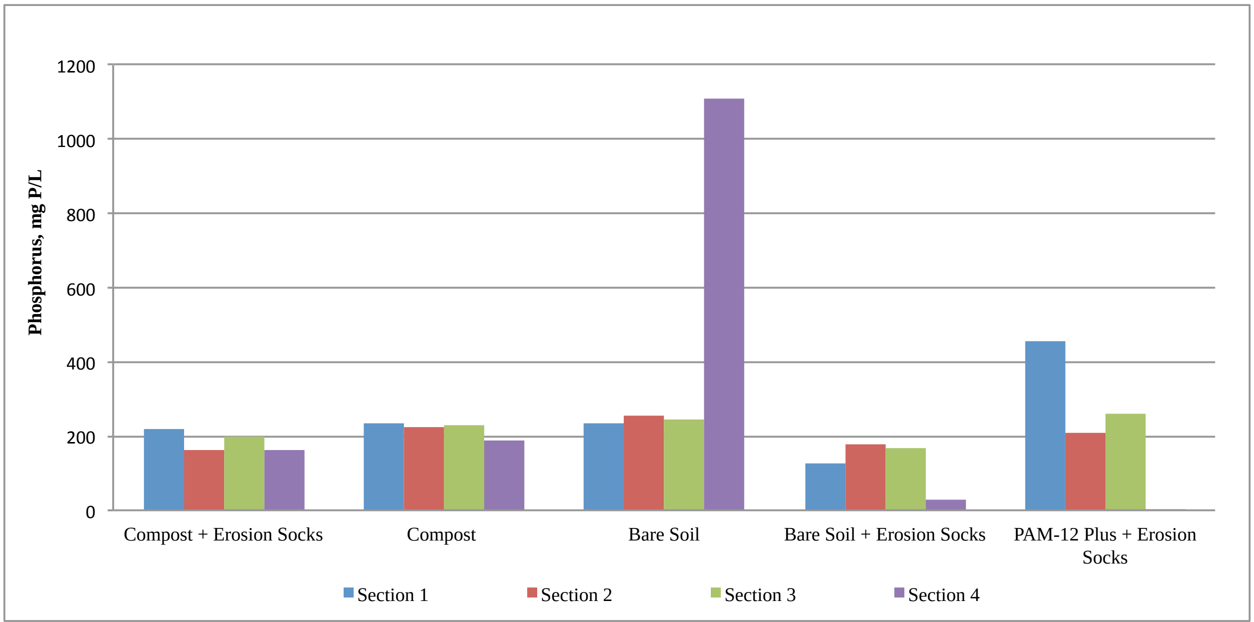


Figure 3.16: Average amount of phosphorus overtime (eight weeks) within plot one (compost + erosion socks), plot two (compost), plot three (bare soil), plot four (bare soil + erosion socks), and plot five (PAM-12 Plus + erosion socks). The data represents the average phosphorus (mg P/L) for an eight week period.

3.2.3 Pathogen Movement

Pathogen movement was monitored for a total of eight weeks. Only *E. coil* was monitored for all eight weeks. *Salmonella* and *Campylobacter* was not detected from the original material of all five plots (data not presented) and were not monitored for eight weeks. On average, for eight weeks, the highest amount of *E. coli* (64.5 MPN/g for all four sections) was identified from plot one (Compost + Erosion socks) (Figure 3.17). However, plot two's (Compost) average for all four sections was only 4.3 MPN/g. Within plot one: section two averages for all eight weeks had the highest detection of *E. coli* (145.8 MPN/g). Plot two: section two only had 1.9 MPN/g (Figure 3.17). Increase detection of *E. coli* within plot one does not compare with the controlled soil column study which showed (<1 *E. coli* MPN) for all five weeks of analysis (Section 4: Table 4.1). The original compost material tested also had <1 MPN/g of detection (Section 2: Table 2.2-2.3). This plot was nearest to the active landfill and had the most vegetative growth. Gulls were observed on this plot, resting, warming, or eating at various times throughout the study. This indicates that surrounding environmental factors may have contributed to the increase in observed *E. coli* levels.

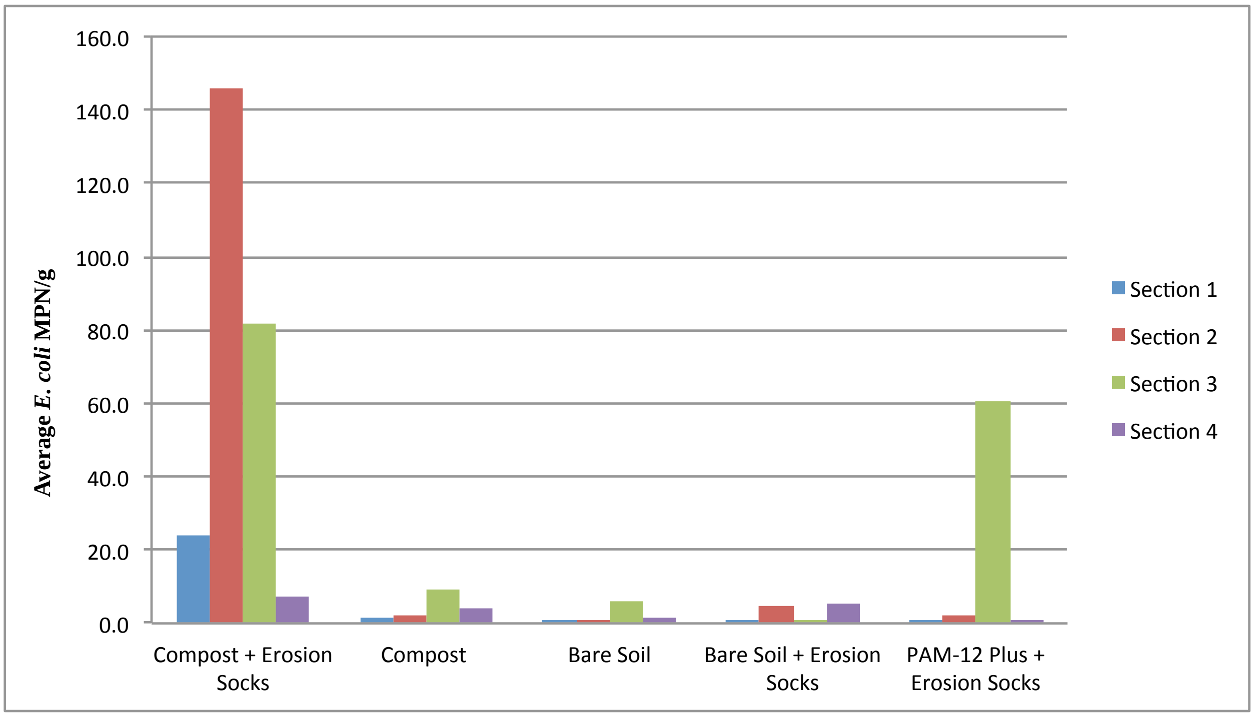


Figure 3.17: Detection of *E. coli* (MPN/g) over an eight weeks within plot one (compost + erosion socks), plot two (compost), plot three (bare soil), plot four (bare soil + erosion socks), and plot five (PAM-12 Plus + erosion socks).

3.2.4 Physical Erosion

Erosion measurements were taken over eight weeks from sections one through four of plots one through five. Figures 3.18 – 3.27 outline the erosion experienced over time with details for each section and averages for each plot. Variation in erosion was observed within sections over time and overall within each plot over time with no real trends observed. It did appear that the two plots with compost did experience more overall negative erosion than the plots without compost (plot one -1.1 cm, plot two -1.56 cm, plot three -0.09 cm, plot four -0.59 cm and plot five 0.41 cm). A separate controlled study would be necessary to determine if this was an artifact of the method used or a result of various environmental factors (rain, wind, compaction, degradation, etc.) present at the site.

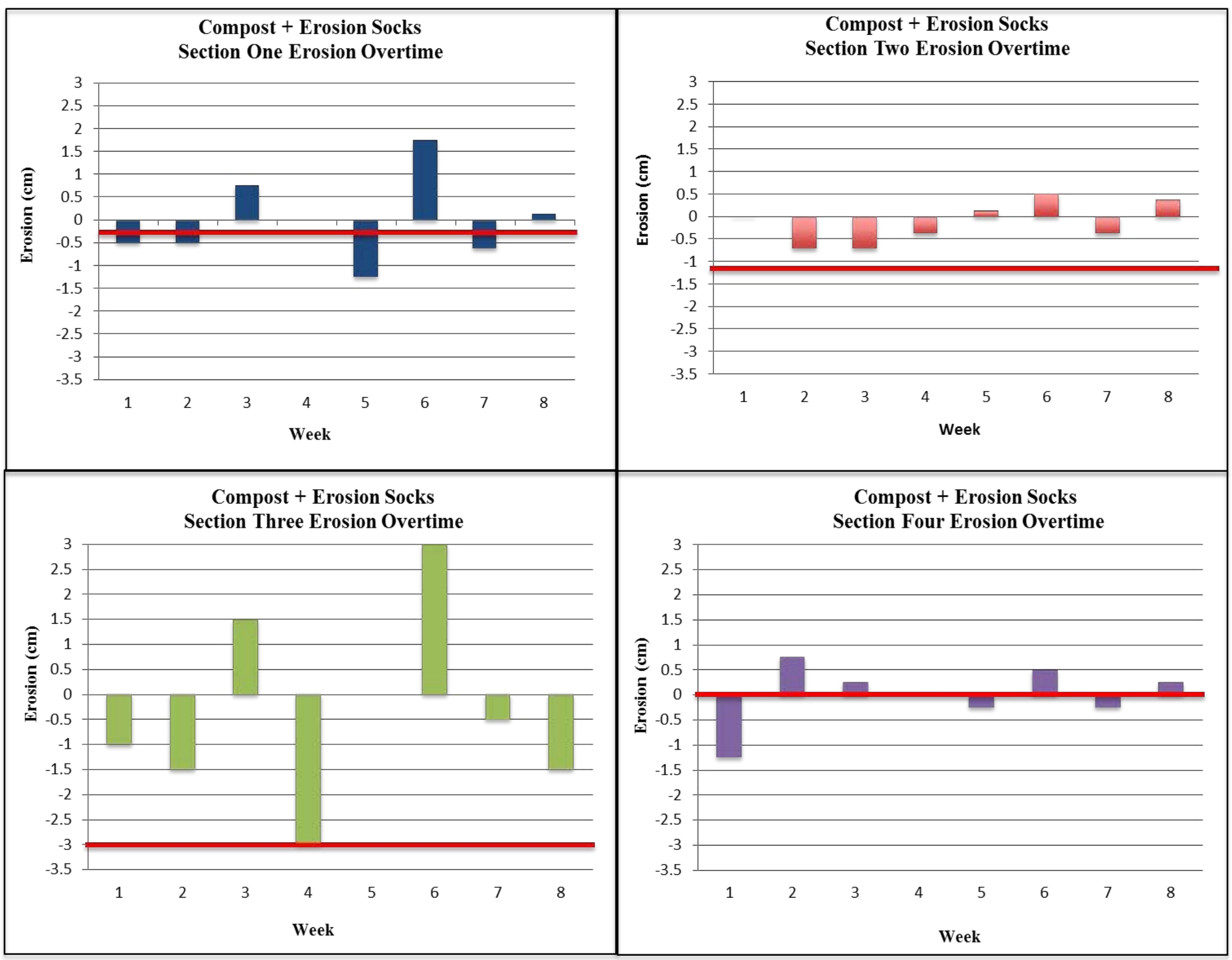


Figure 3.18: Plot one (compost + erosion socks) amount of erosion overtime for sections one through four. The red line (---) indicates overall sum of erosion over eight weeks.

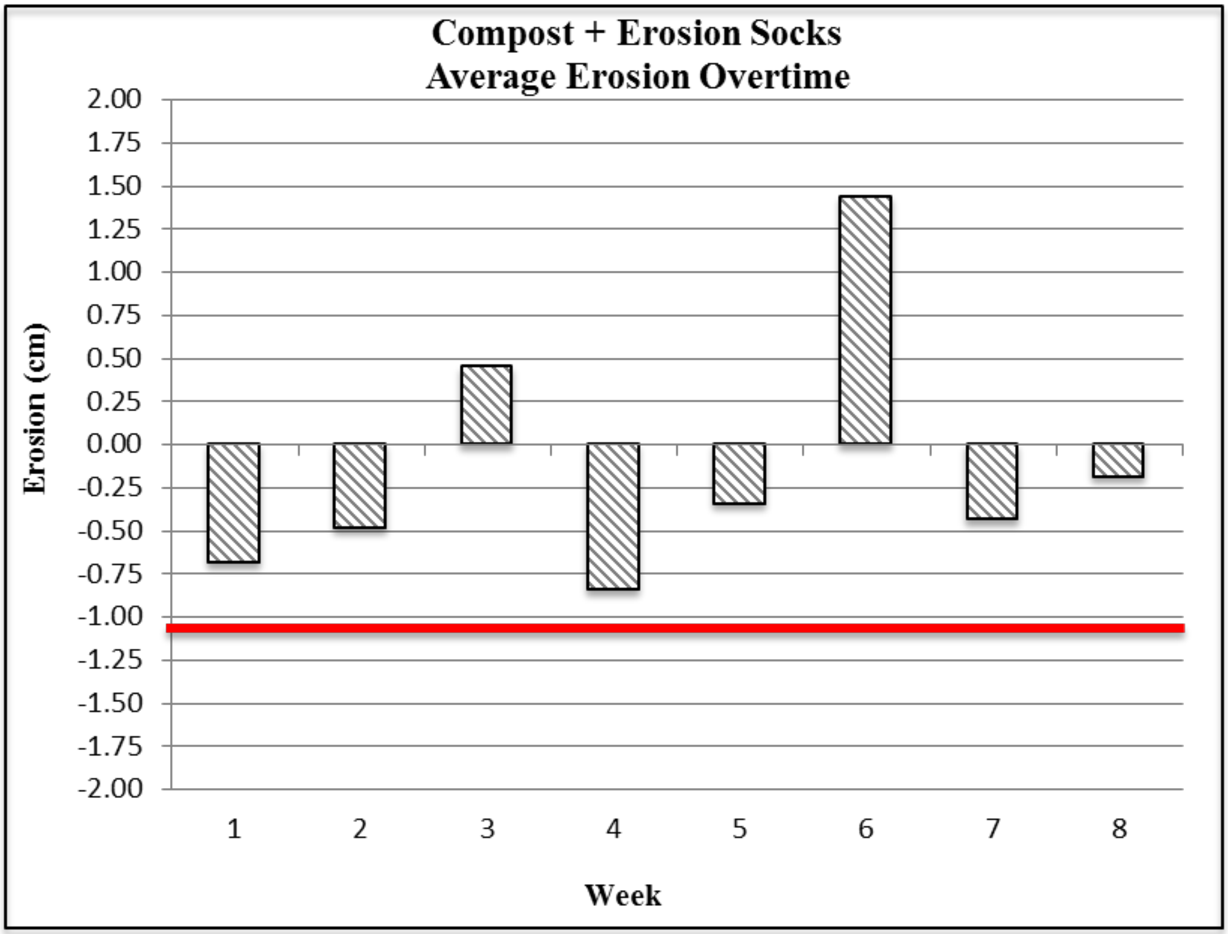


Figure 3.19: Plot one (compost + erosion socks) average erosion overtime for all four sections. The red line (---) indicates overall sum of erosion over eight weeks.

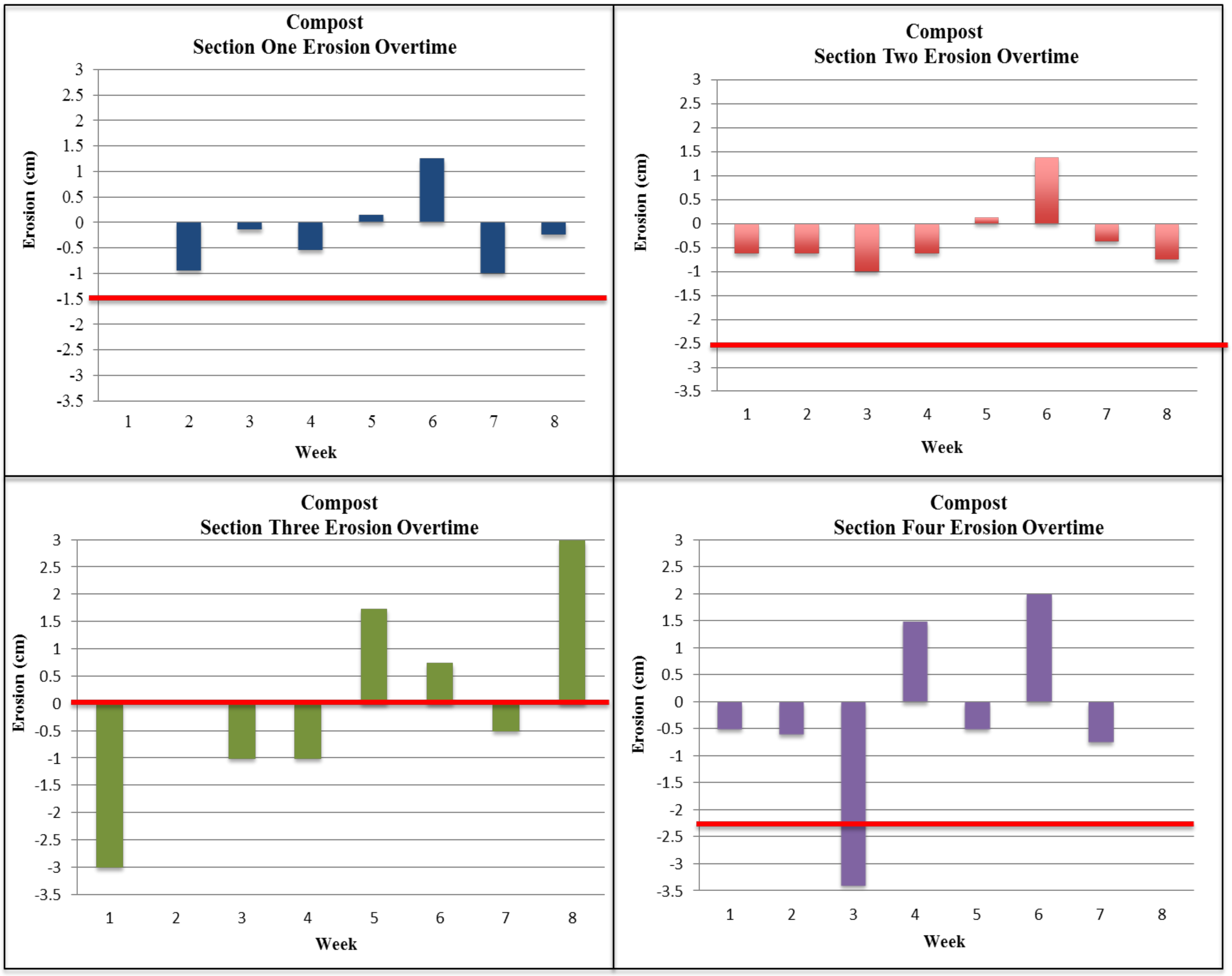


Figure 3.20: Plot two (compost) amount of erosion overtime for sections one through four. The red line (---) indicates overall sum of erosion over eight weeks.

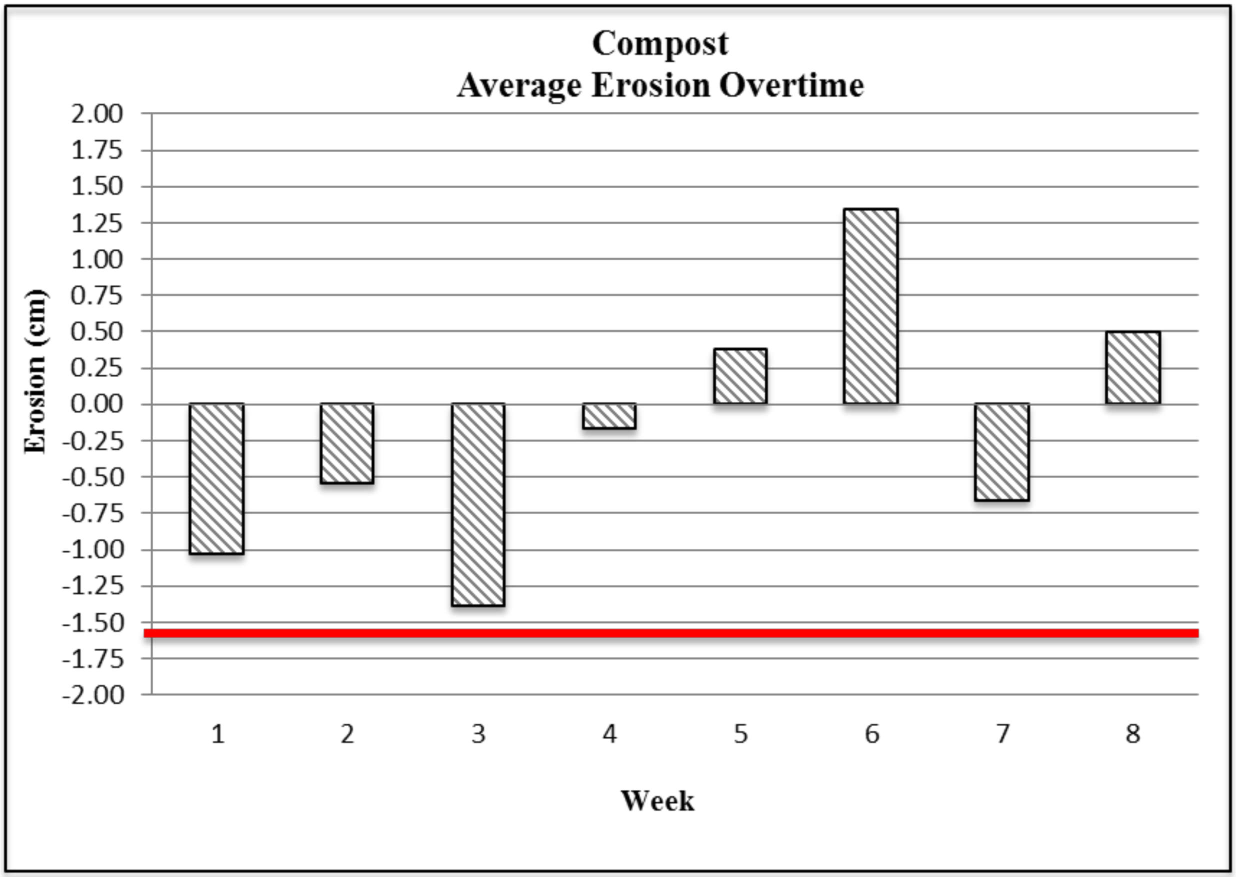


Figure 3.21: Plot two (compost) average erosion overtime for all four sections. The red line (---) indicates overall sum of erosion over eight weeks.

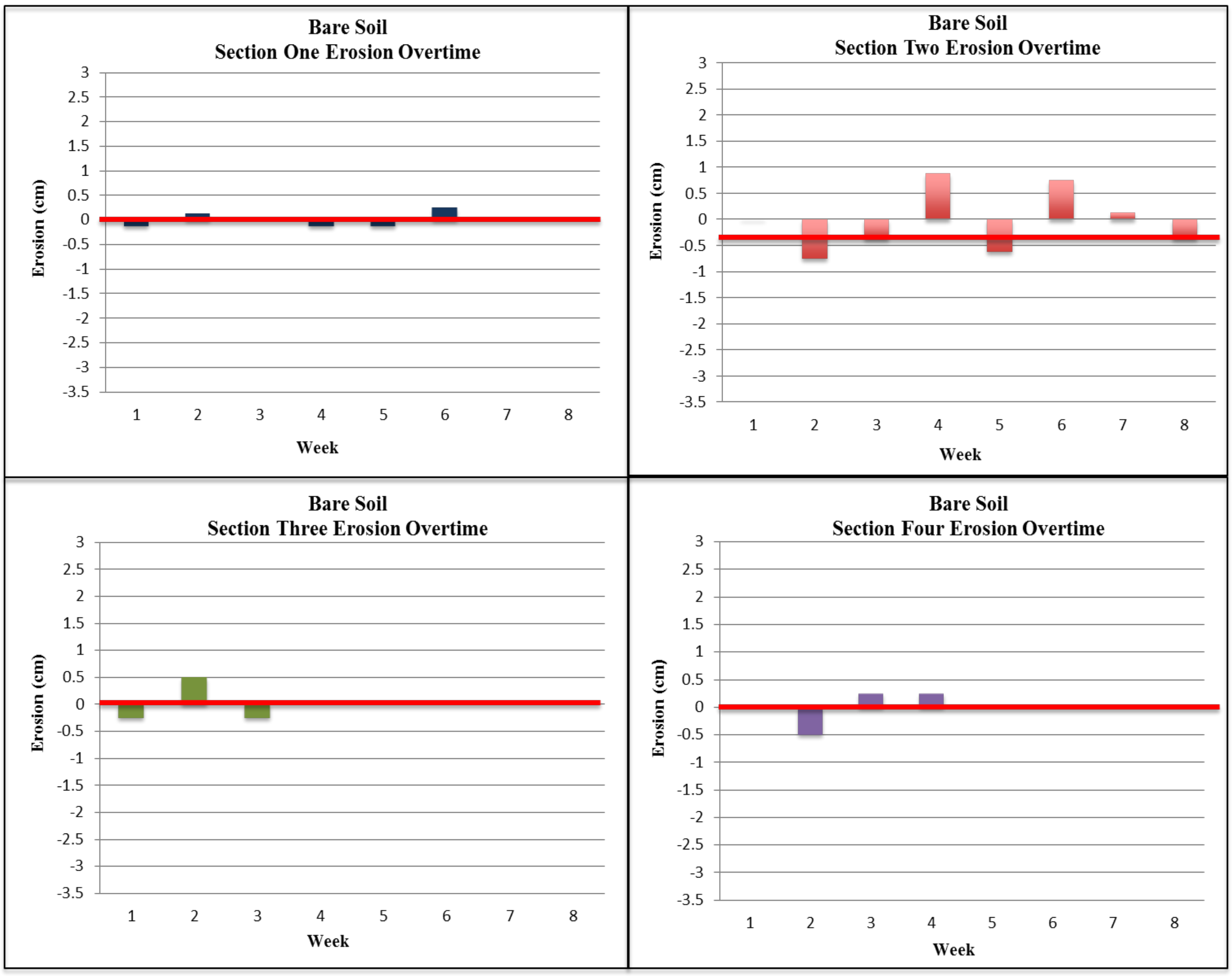


Figure 3.22: Plot three (bare soil) amount of erosion overtime for sections one through four. The red line (---) indicates overall sum of erosion over eight weeks.

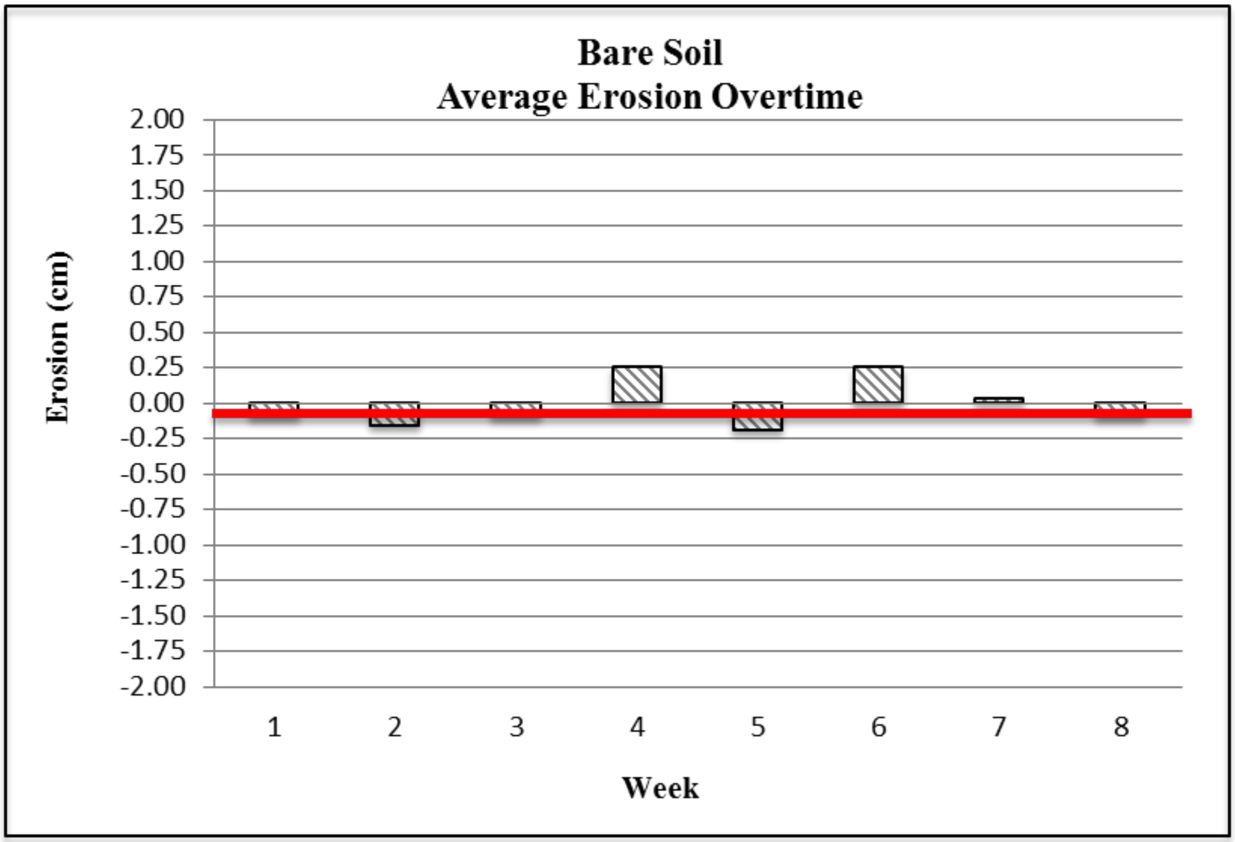


Figure 3.23: Plot three (bare soil) average erosion overtime for all four sections. The red line (---) indicates overall sum of erosion over eight weeks.

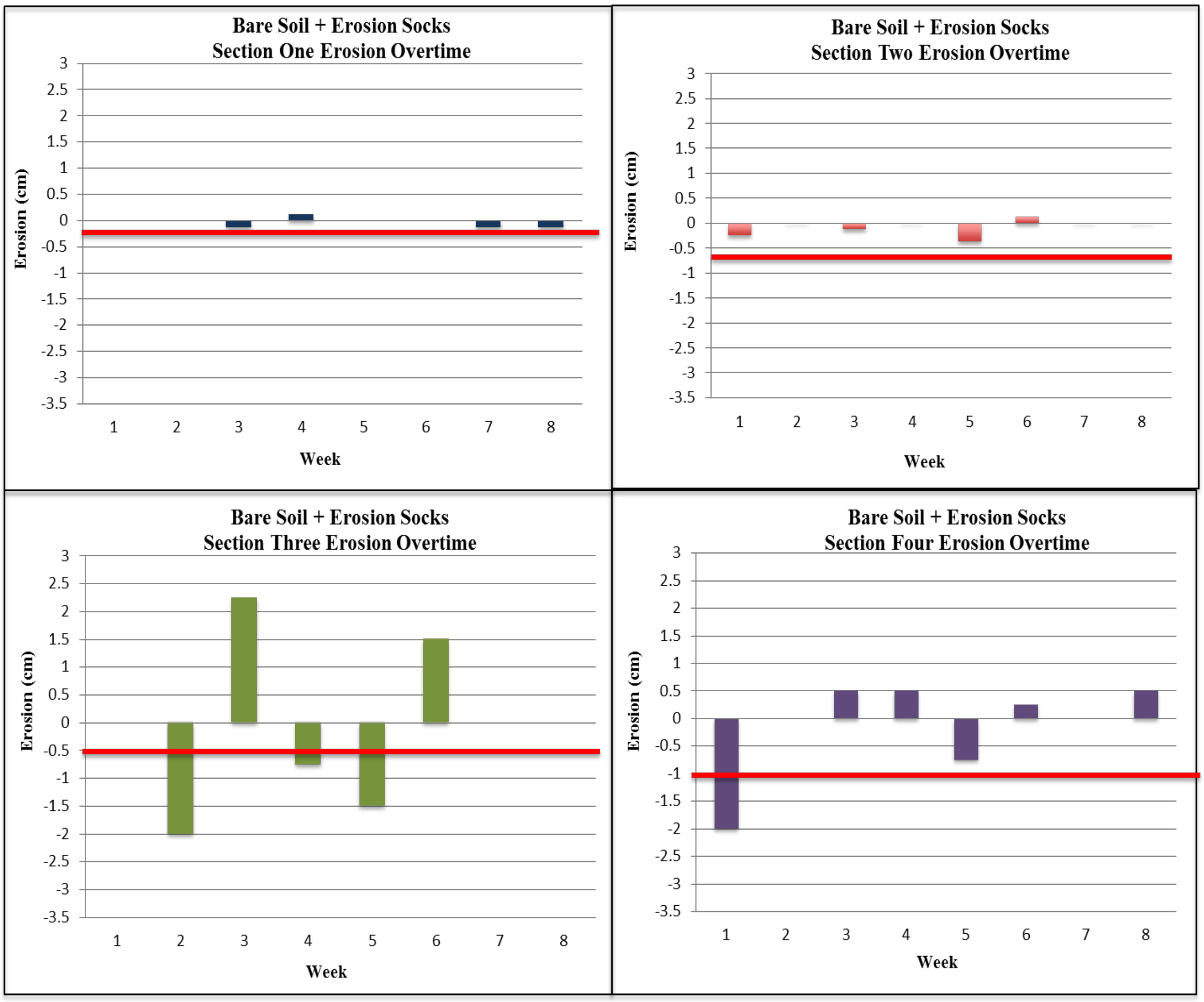


Figure 3.24: Plot four (bare soil + erosion socks) amount of erosion overtime for sections one through four. The red line (---) indicates overall sum of erosion over eight weeks.

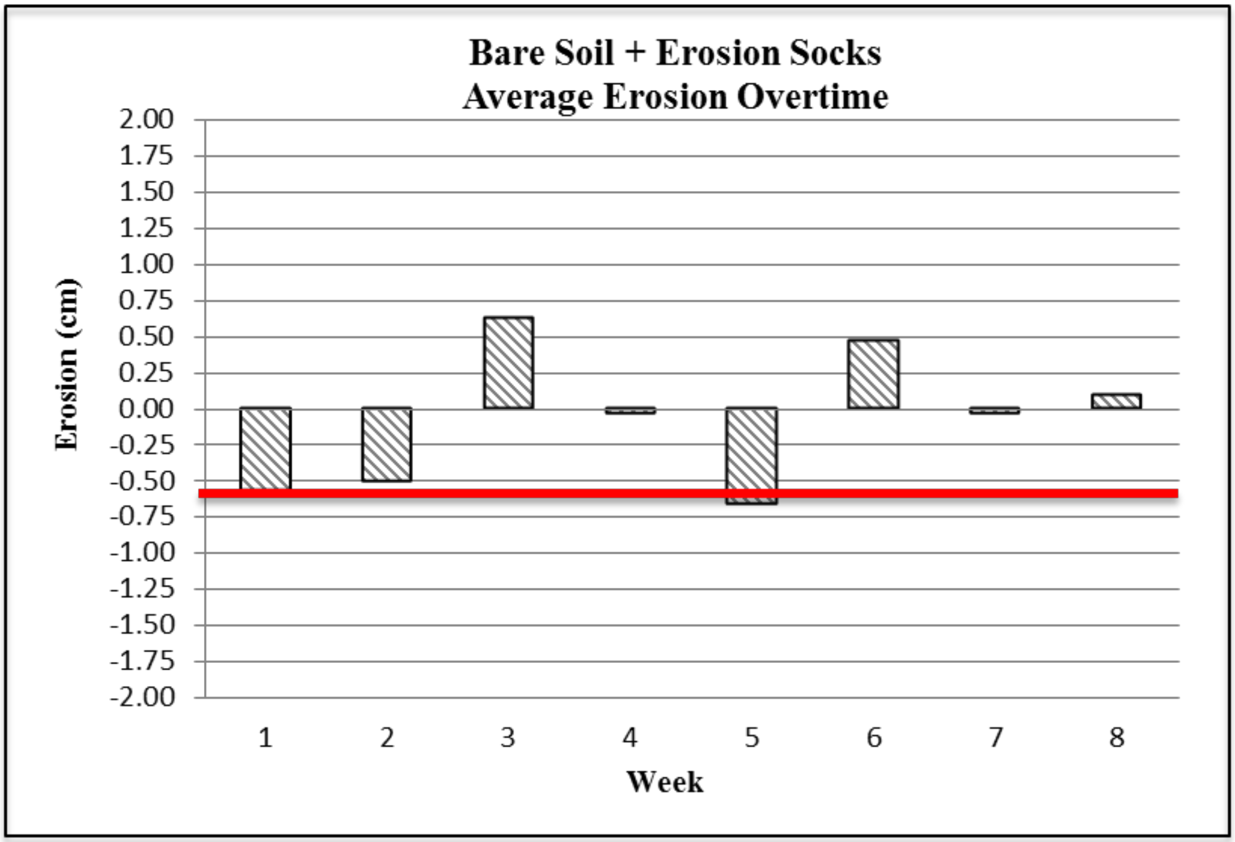


Figure 3.25: Plot four (bare soil + erosion socks) average erosion overtime for all four sections. The red line (---) indicates overall sum of erosion over eight weeks.

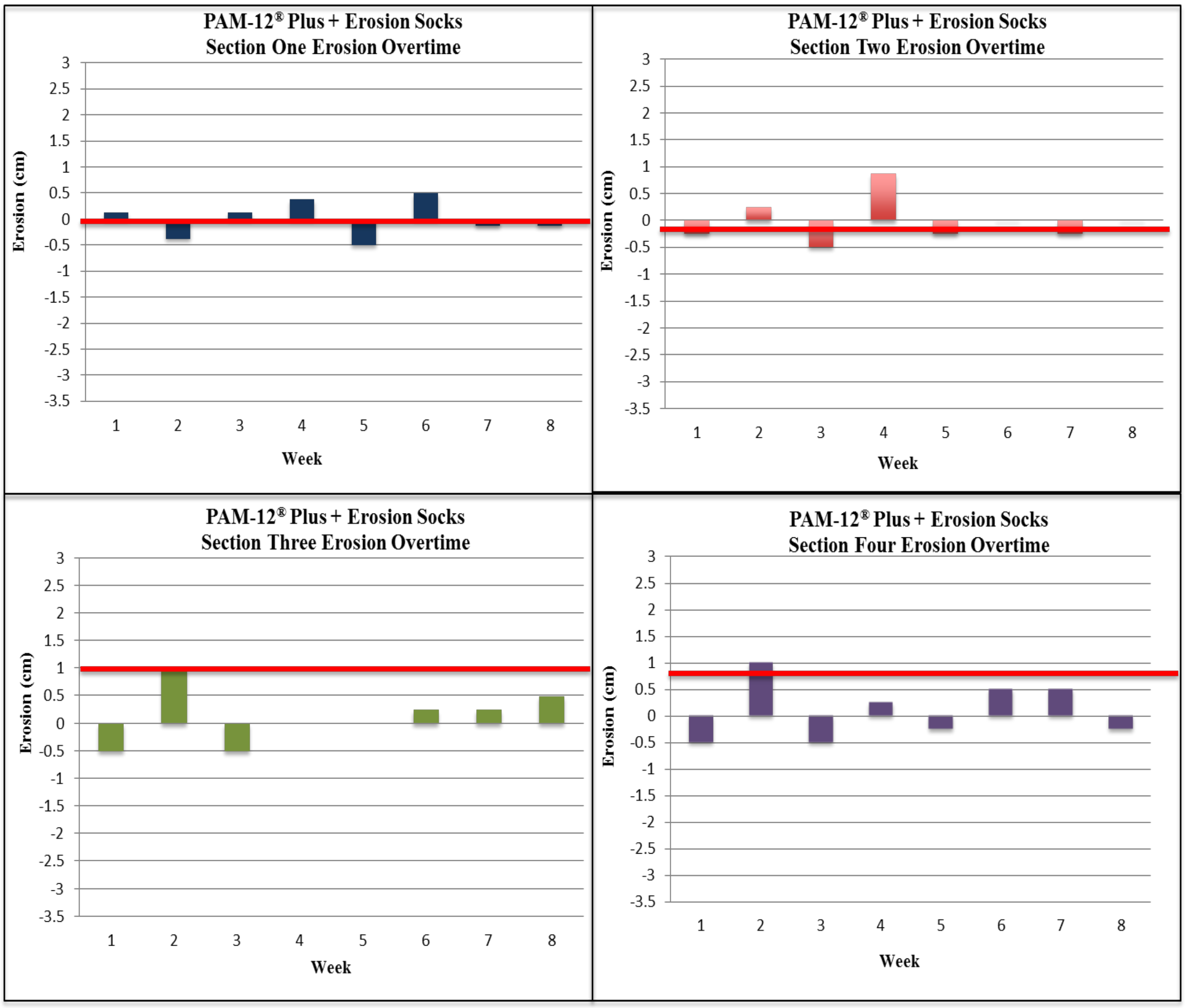


Figure 3.26: Plot five (PAM-12® Plus + erosion socks) amount of erosion overtime for sections one through four. The red line (---) indicates overall sum of erosion over eight weeks.

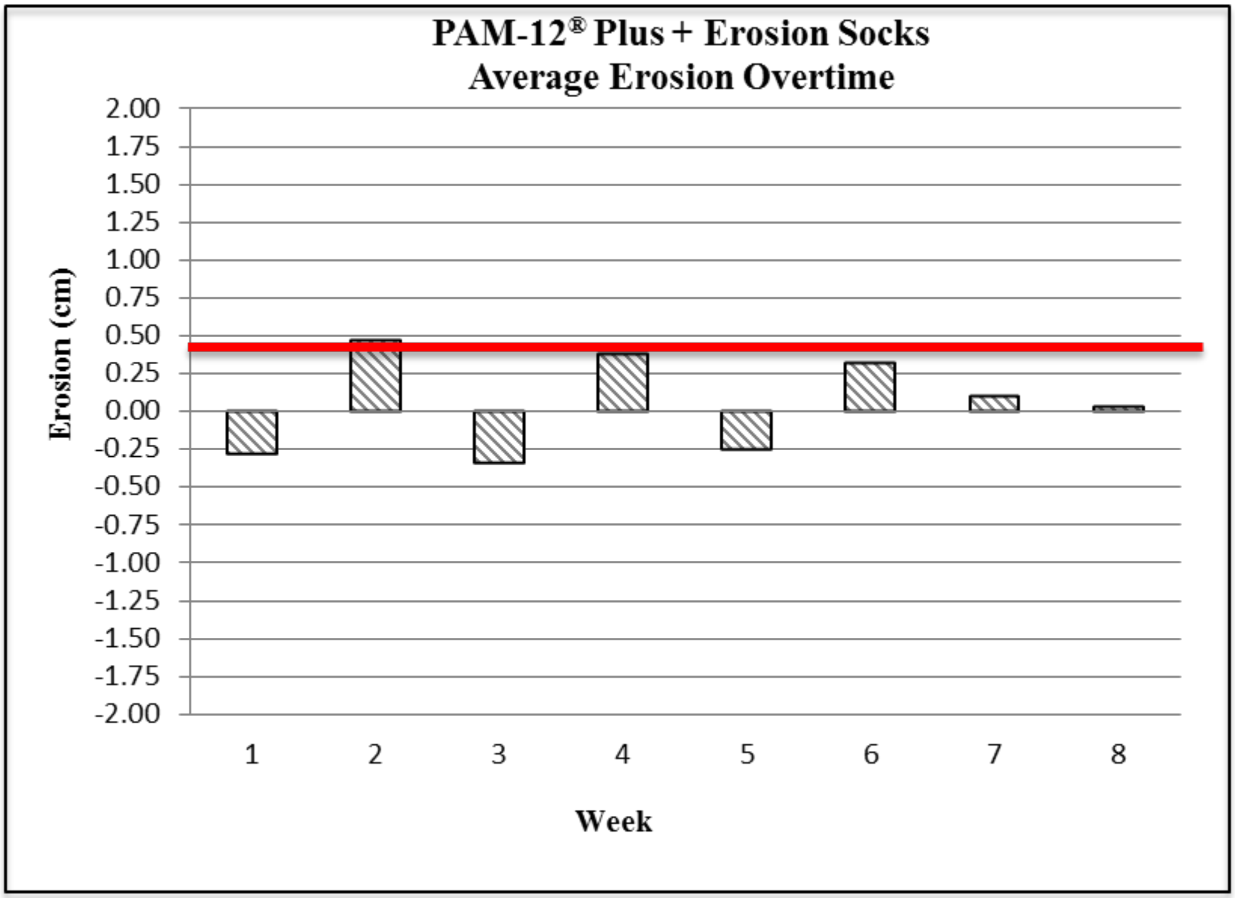


Figure 3.27: Plot five (PAM-12® Plus + erosion socks) average erosion overtime for all four sections. The red line (---) indicates overall sum of erosion over eight weeks.

3.3 Conclusions

- Compost plots (one and two) generally demonstrated a more even establishment of grass growth over the duration of the study compared to bare soil and PAM-12 Plus (plots three, four, and five).
- Grass establishment was comparable between compost plots (one and two) and the erosion mat / hydro mulch plot (plot six)
- Little variation was observed in overall nutrient levels between sections within each plot, indicating minimal nutrient movement within the plots.
- Calcium, nitrogen and potassium showed some difference when comparing compost plots to non-compost plots, however magnesium and phosphorous levels were relatively similar across all plots.
- Calcium levels were approximately two times higher in compost vs. non-compost plots, nitrogen was approximately nine times higher in compost vs. non-compost plots and potassium was approximately two times lower in compost vs. non-compost plots.
- Erosion socks did not appear to have any affect on the levels of nutrients detected over the duration of the study when compared to plots without erosion socks.
- *Salmonella* and *Campylobacter* were not detected from plots one through five.
- *E. coli* detection was negligible and most likely impacted by surrounding environmental factors.
- On average it appears that more overall negative erosion occurred from the compost plots vs. the non-compost plots, however it was unclear from the data what caused this. (plot one: -1.1 cm, plot two: -1.56 cm vs. plot three: -0.09 cm, plot four: -0.59 cm, and plot five: 0.41 cm)
- It is recommended that an additional laboratory study should be conducted to evaluate and/or validate under controlled conditions the negative erosion, which was observed in the landfill demonstration.
- Erosion socks did not appear to have any consistent affect on the amount of erosion when comparing compost to non-compost plots.
- To elucidate clear patterns between rainfall and erosion more rainfall data would need to be collected. Additionally a controlled rain study could be conducted.

4. NUTRIENT LOSS AT A LABORATORY SCALE

It is beneficial to have material that is high in nutrient content and can sustain the nutrient levels over months or years unlike bare soil or synthetic fertilizers. Biological, bacterial pathogens, parameters were analyzed to assess the safety, presence and loss overtime. To analyze such loss overtime, laboratory scale nutrient loss analysis was conducted. Soil columns were utilized for monitoring nutrient and biological loss over time. The assessment of nutrient and biological loss over time was conducted once a week for a span of five weeks. The nutrients included calcium (Ca), magnesium (Mg), potassium (K), total nitrogen (N), and total phosphorus (P). The biological parameters included Total coliforms, *E. coli*, *Salmonella*, and *Campylobacter*.

4.1. Procedure

A. Utilize a soil column for monitoring nutrient and pathogen loss.

B. Monitoring occurred weekly throughout the duration of the study.

C. Laboratory scale mimicked the pilot scale units in scope and applicability.

D. Garden plot soil, compost and screen compost were analyzed separately and in 50:50 ratios. A total of 3,000 g of material was loaded into each column. The columns containing two mixtures had 1,500 g of each material.
   - a. Approximately 700 mL of water was run through the columns each week. Following seven days the collected column effluent was quantified for nutrients and *E. coli* (Sections G and H).
   - b. A total of six experimental designs were evaluated (Figure 4.1).
     1. Soil alone column
     2. Soil + Compost (50:50) column
     3. Soil + Screened Compost (50:50) column
     4. Compost column
     5. Screened Compost column
     6. Compost + Screened Compost column

E. Bacterial inoculation
   - a. The columns were sterilized and two columns were filled with soil and compost. A total of 3,000 g of material was loaded into each column.
   - b. The two columns were inoculated with *E. coli* (648.8 MPN/100mL). A total of 500 mL of inoculated water was run through each of the two columns.
   - **c.** The water was allowed to saturate through the columns and was collected post seven days. The collected column effluent was quantified for *E. coli*.

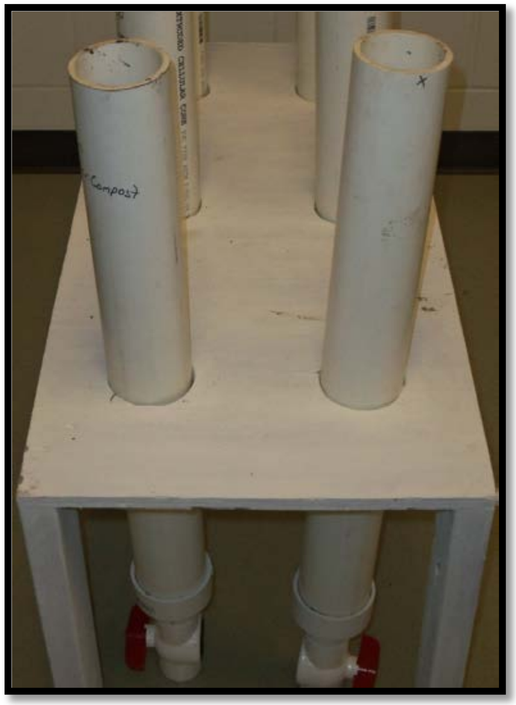


Figure 4.1: Laboratory scale soil columns used for evaluating nutrient loss over time from City of Appleton compost material and the garden plot soil.

F. Nutrient loss

a. Evaluation of nutrient content prior to the start of the study and once a week during the period of the study.
b. Nutrients included:
    1.Total Nitrogen (N)
    2.Total Phosphorus (P)
    3.Potassium (K)
    4.Magnesium (Mg)
    5.Calcium (Ca)

G. Pathogen movement

a. Evaluation of the pathogen movement prior to the start of the study and once a week during the study.
b. Pathogens Include:
    1.Total coliforms / *E. coli* (Most Probable Number: MPN/100ml)
    2.Salmonella (Colony Forming Units per gram: CFU/g)
    3.Campylobacter (Colony Forming Units per gram: CFU/g)

4.2 Results and Discussion

Compost contains macro and micronutrients often absent or present at lower levels in the soil. Compost can release nutrients slowly over months or years unlike plain soil. The laboratory scale experiment helped visualize this over a five week study. First week analyses of column effluent (6 August) showed that the unscreened compost and screened compost had higher levels of nutrients in comparison to soil. Calcium however was lower in screened compost (740 mg/Kg) in comparison to soil (860 mg/Kg). The level of potassium detected was significantly lower in soil (66 mg/Kg) in comparison to unscreened compost (1,200 mg/Kg) and screened compost (1,000 mg/Kg). The calcium, magnesium, and potassium levels declined by half (50%) by week two and continued to decline throughout the remaining period of the study. The decline of macro and micronutrients in a real life garden or agricultural setting after a heavy rainfall event may impact plant growth and health for the growing season. Thus, it is beneficial to have material that is high in nutrient content that can release nutrients slowly over months or years unlike bare soil or synthetic fertilizers.

The unscreened and screened compost (0.5568 and 0.5748 % ww^{-1} dw) had higher water holding capacity in comparison to regular ground soil (0.4123% ww^{-1} dw). Similar results were visualized in the soil columns filled with those three separate materials (Figure 4.2). Post (48 hours) water runoff, only the columns with unscreened, screened compost, and the 50:50 had water saturated through the columns. Meanwhile, the three columns with soil or 50:50 mixtures of soil and compost had water remaining on the top of the columns. Throughout the five week span similar saturation rates were visualized for all of the six columns. Greater amount of water had trickled through the three compost columns in comparison to the columns filled with soil and soil plus compost. This was most likely a result of the particle size differences between the compost and soil (Table 2.1 and 2.2). The smaller particle size of the soil most likely resulted in early compaction of the resulting columns. The increased seepage of water through the compost columns may have impacted the higher loss of nutrients within column effluent in comparison to the soil columns.

Of the pathogens targeted, no pathogens were detected in compost and screened compost material. *Salmonella* and *Campylobacter* were not detected from the six column setups (data not presented). Coliform bacteria was detected at >2,419.6 MPN/100 mL for all columns for the week one collection day. By week five, the Coliform count for soil (373 MPN/100 mL), compost (187 MPN/100 mL), and screened compost (450 MPN/100 mL) had decreased by minimum of 80%. *E. coli* was only detected in columns containing garden plot soil. No presence of *E. coli* was detected within compost, screened compost, or compost + screened compost mixture. The week five analysis showed no detection of *E. coli* within any of the six experimental setups.

For the final phase of the column experiment, the columns were inoculated with *E. coli* to assess the composts ability to incubate and increase or decrease the survivability of the organism. No *E. coli* was detected from the soil and compost column setups. Additional 500 mL (*E. coli* free) water was run through in similar manner for additional two weeks. Similar to before, no *E. coli* was detected. This is essential and demonstrates that the compost does not incubate and increase the survivability of *E. coli*.

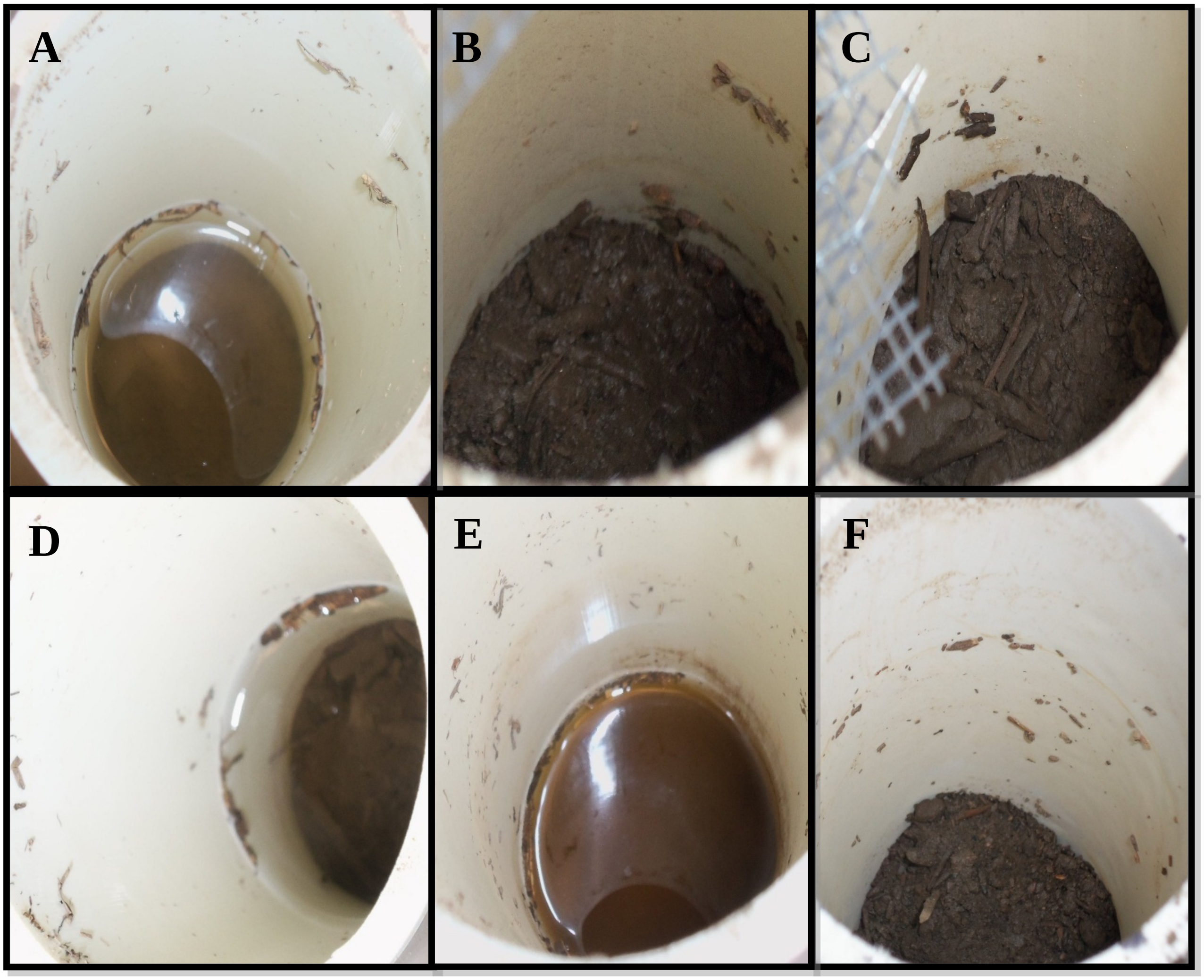
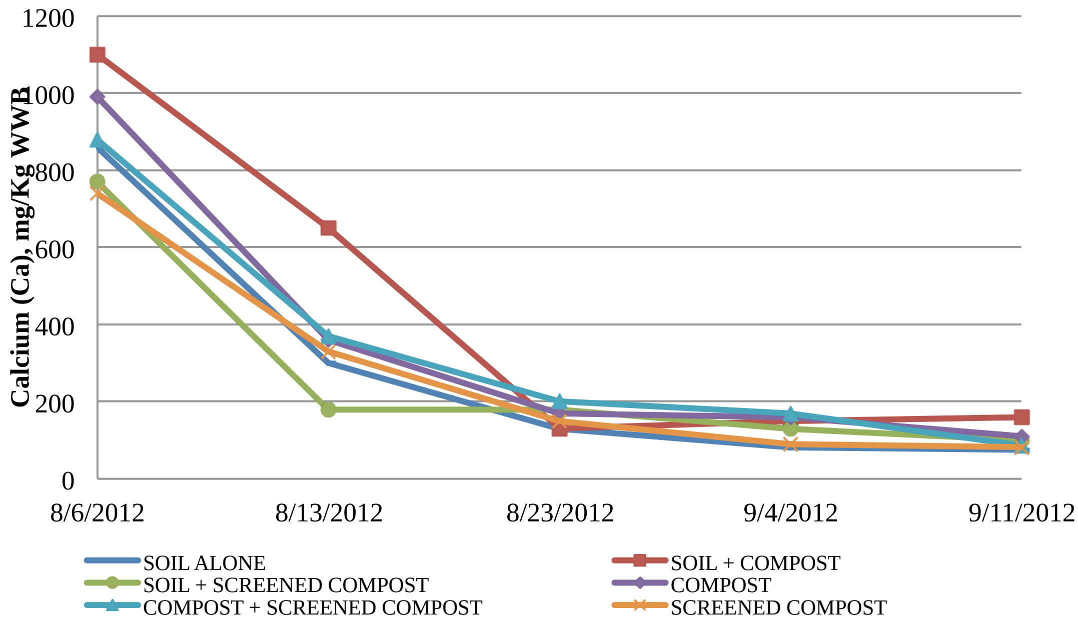


Figure 4.2: Overview of the soil columns 48 hours post water (700 mL) run-off. **A)** Soil **B)** Screened Compost **C)** Unscreened Compost **D)** Soil + Compost **E)** Soil + Screened Compost and **F)** Compost + Screened Compost

A.



B.

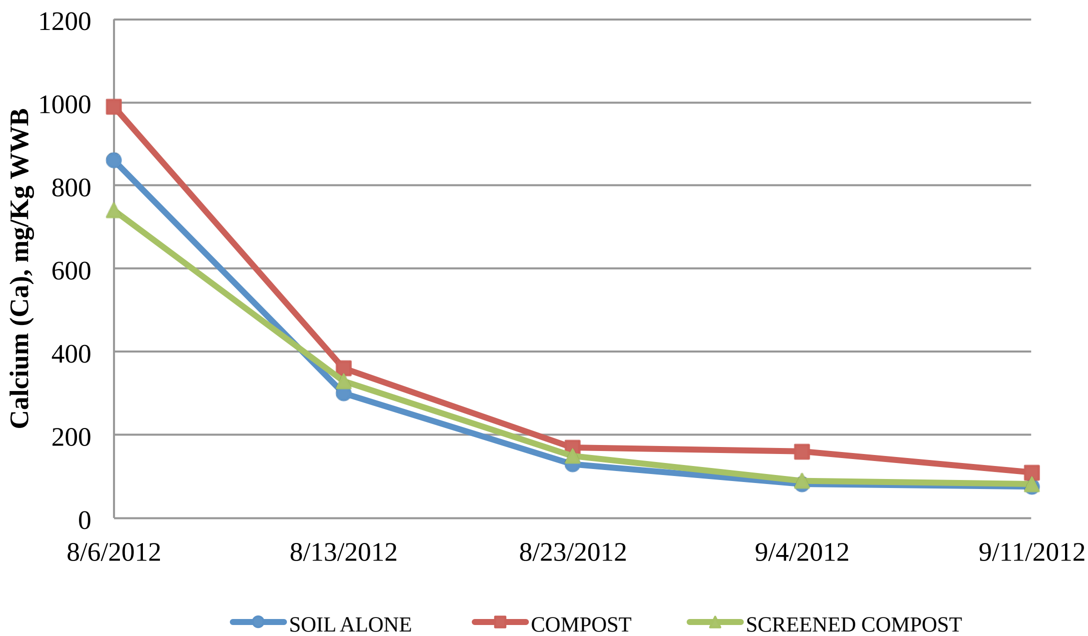
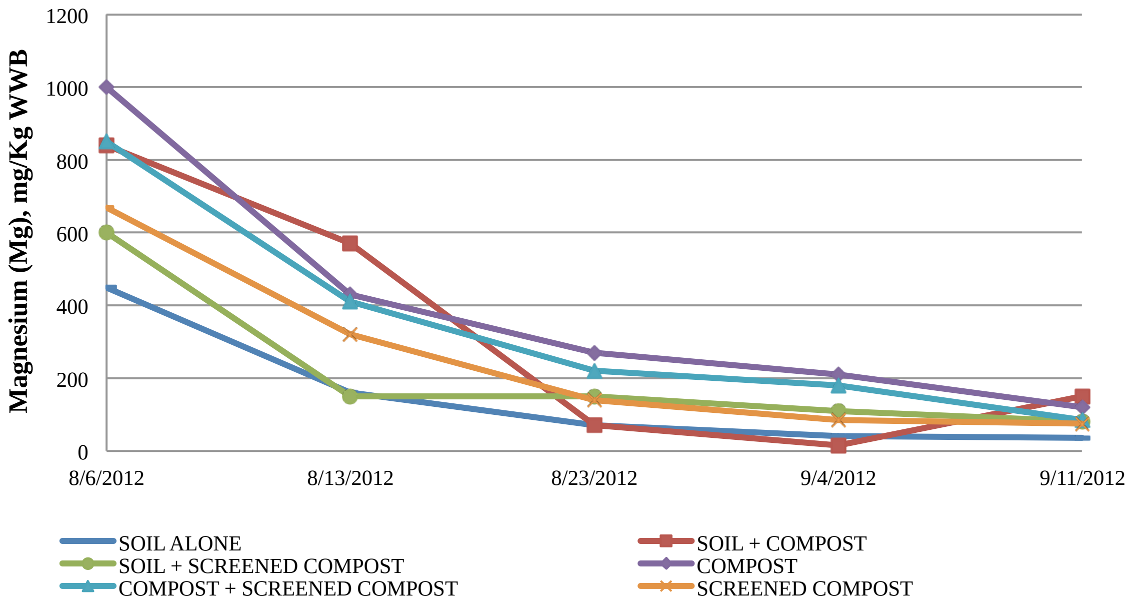


Figure 4.3: Evaluation of calcium (Ca mg/Kg) loss over five week period within Soil, Soil + compost, Soil + Screened compost, Compost, Compost + Screened compost, and Screened compost filled columns. **A)** The analysis of all six experimental designs **B)** Analysis of Soil, Compost, and Screened compost

A.



B.

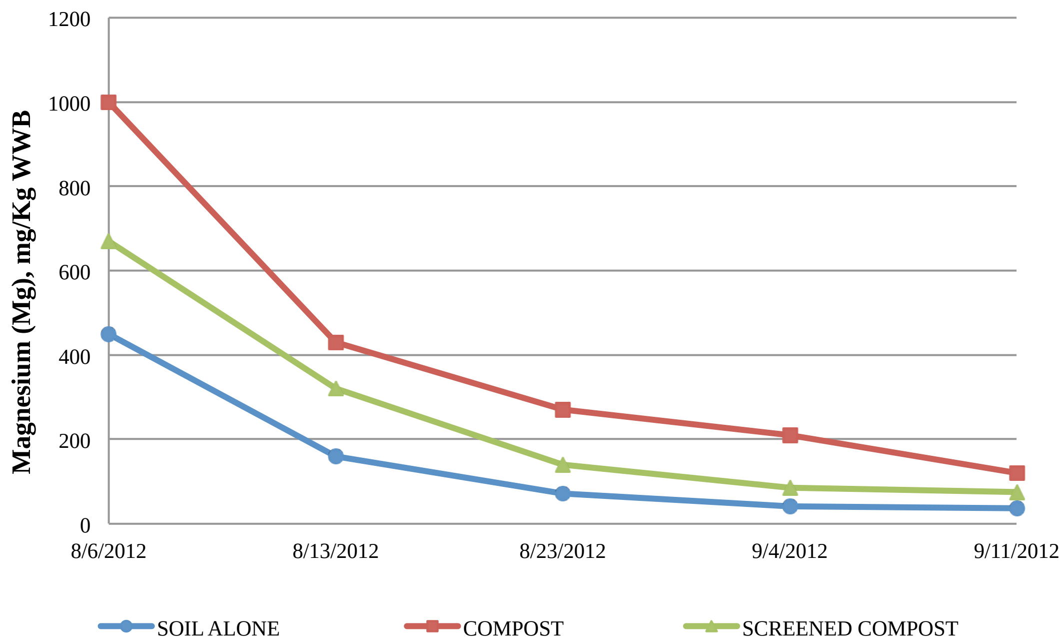
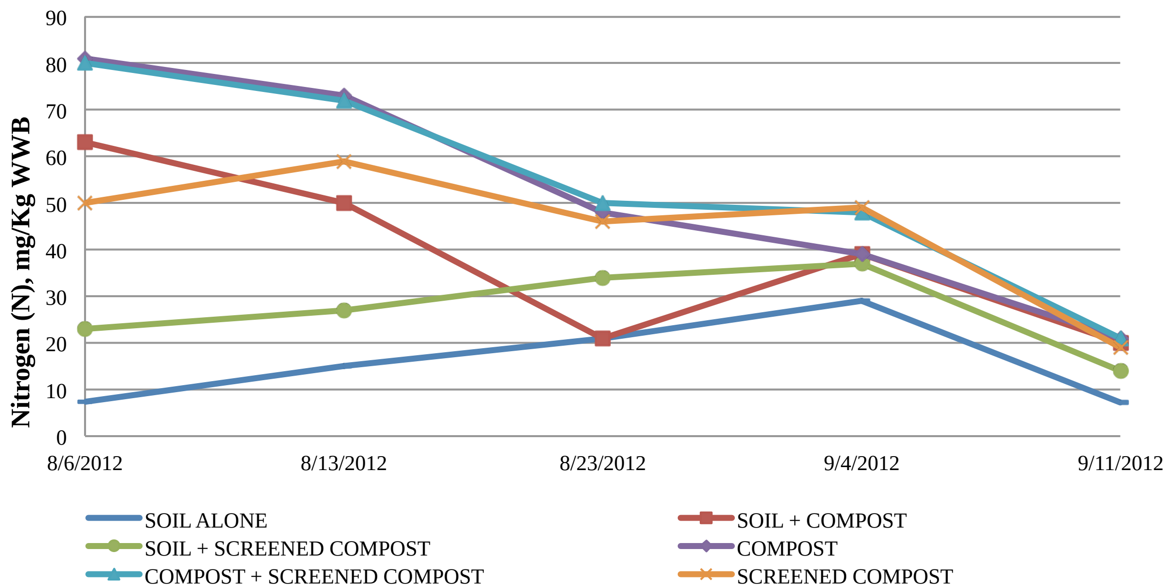


Figure 4.4: Evaluation of magnesium (Mg mg/Kg) loss over five week period within Soil, Soil + Compost, Soil + Screened compost, Compost, Compost + Screened compost, and Screened compost filled columns. **A)** The analysis of all six experimental designs **B)** Analysis of Soil, Compost, and Screened compost

A.



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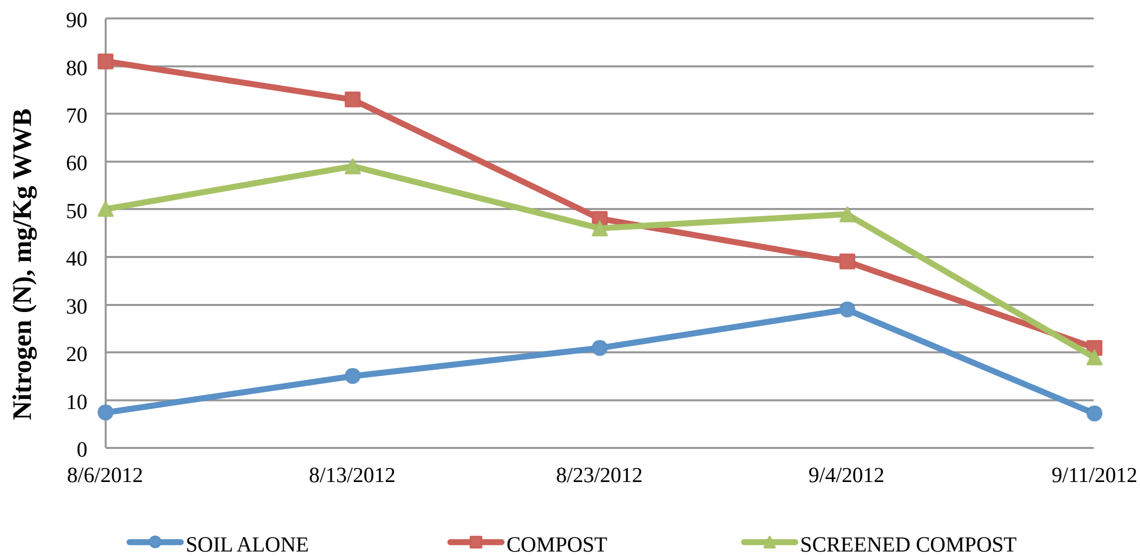
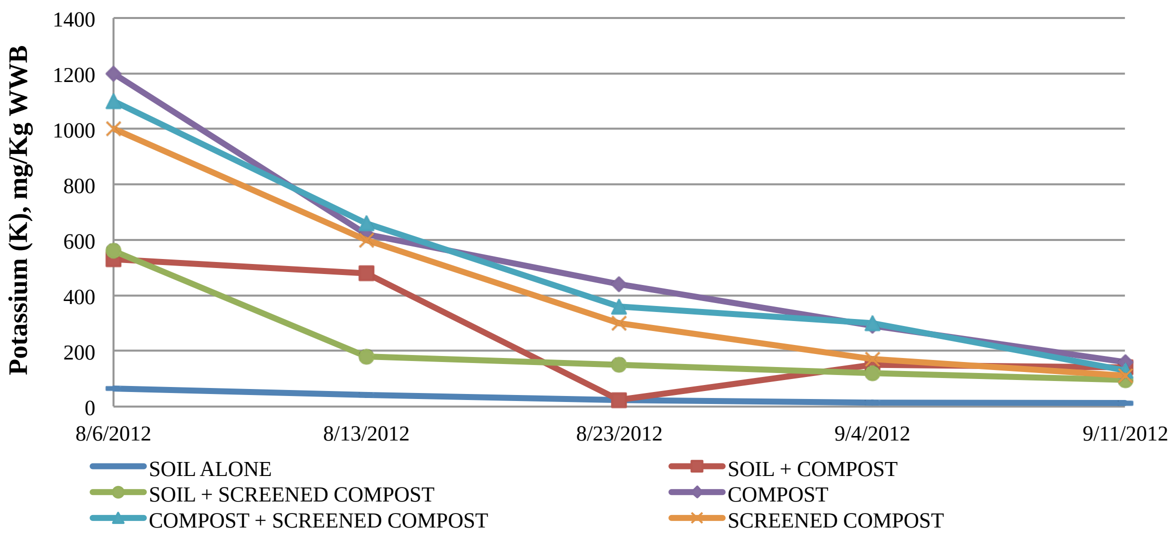


Figure 4.5: Evaluation of nitrogen (N mg/Kg) loss over five week period within Soil, Soil + Compost, Soil + Screened compost, Compost, Compost + Screened compost, and Screened compost filled columns. **A)** The analysis of all six experimental designs **B)** Analysis of Soil, Compost, and Screened compost

A.



B.

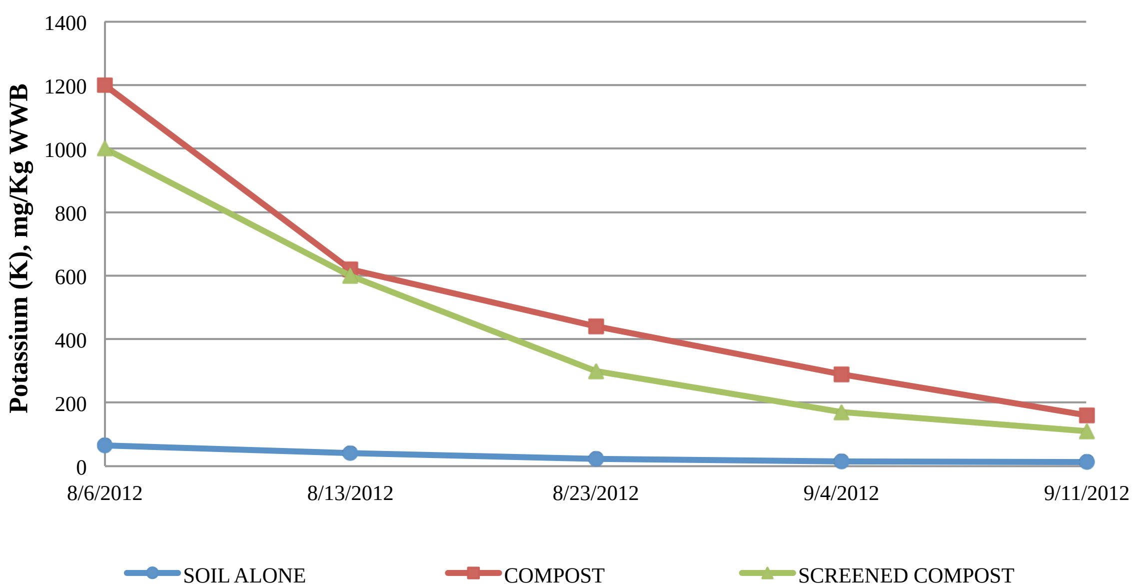
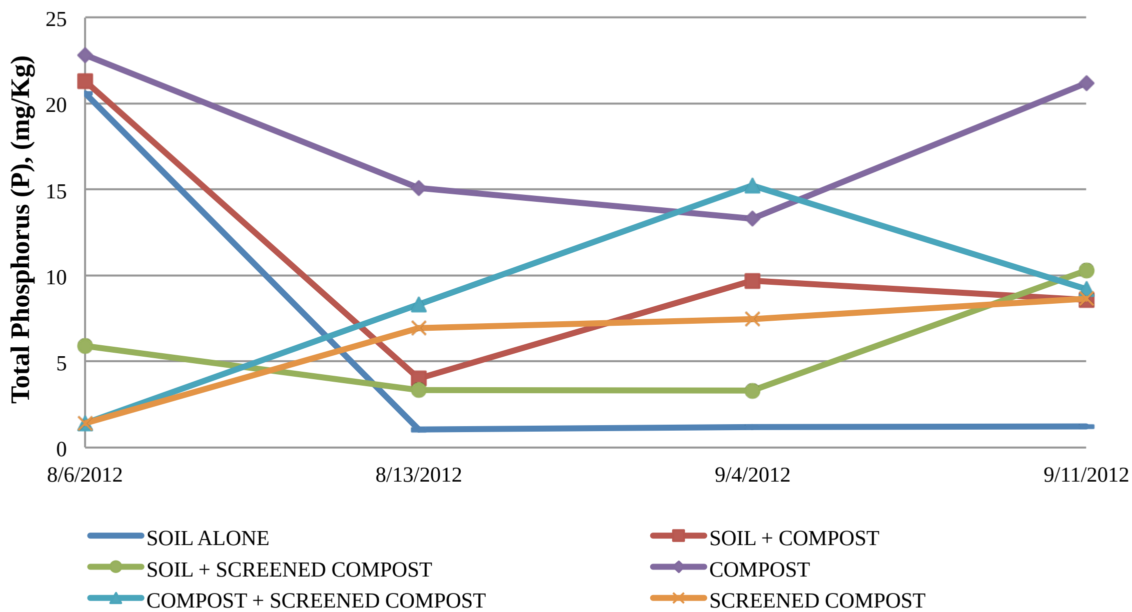


Figure 4.6: Evaluation of potassium (K mg/Kg) loss over five week period within Soil, Soil + Compost, Soil + Screened compost, Compost, Compost + Screened compost, and Screened compost filled columns. **A)** The analysis of all six experimental designs **B)** Analysis of Soil, Compost and Screened compost

A.



B.

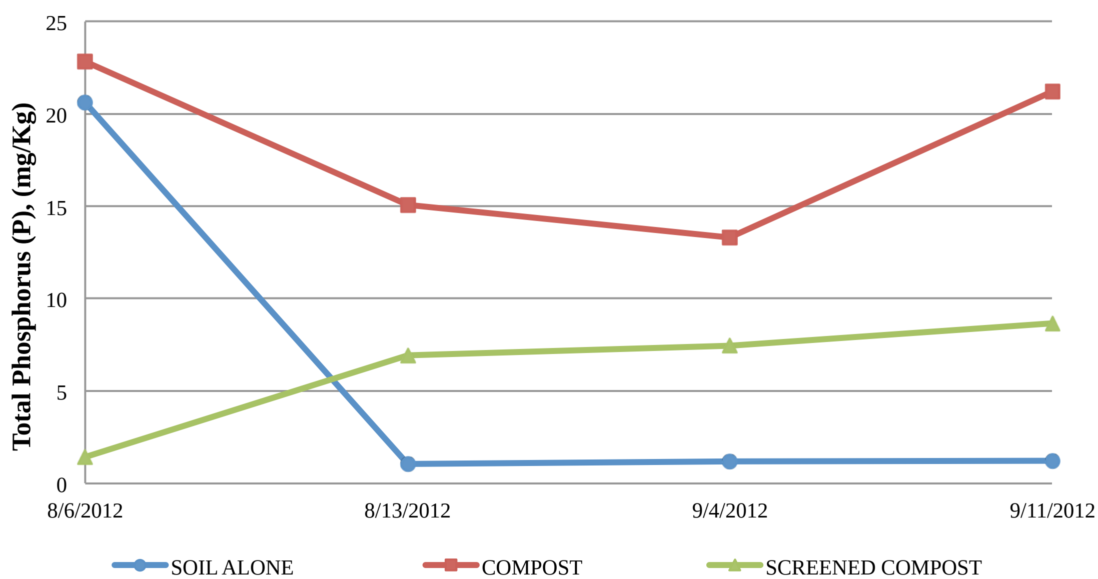


Figure 4.7: Evaluation of total phosphorus (P mg/Kg) loss over five week period within Soil, Soil + Compost, Soil + Screened compost, Compost, Compost + Screened compost, and Screened compost filled columns. **A)** The analysis of all six experimental designs **B)** Analysis of Soil, Compost, and Screened compost

Table 4.1: Evaluation of Coliform bacteria and *E. coli* (MPN/100 mL) over five week period within Soil, Soil + Compost, Soil + Screened compost, Compost, Compost + Screened compost and Screened compost filled columns.

	Biological Parameters					
Coliform bacteria (MPN/100mL)						
Collection Date	**SOIL ALONE**	**SOIL + COMPOST**	**SOIL + SCREENED COMPOST**	**COMPOST**	**COMPOST + SCREENED COMPOST**	**SCREENED COMPOST**
8/6/2012	>2,419.6	>2,419.6	>2,419.6	>2,419.6	>2,419.6	>2,419.6
8/13/2012	>2,419.6	>2,419.6	>2,419.6	>2,419.6	>2,419.6	>2,419.6
8/23/2012	2,419.6	410.6	>2,419.6	172	>2,419.6	>2,419.6
9/4/2012	1,396	>2,419.6	>2,419.6	189	>2,419.6	857
9/11/2012	373	>2,419.6	>2,419.6	187	738	450
E. coli (MPN/100mL)						
Collection Date	**SOIL ALONE**	**SOIL + COMPOST**	**SOIL + SCREENED COMPOST**	**COMPOST**	**COMPOST + SCREENED COMPOST**	**SCREENED COMPOST**
8/6/2012	65.5	55	10	<1	<1	<1
8/13/2012	<1	<1	<1	<1	<1	<1
8/23/2012	1	1	<1	<1	<1	<1
9/4/2012	<1	<1	<1	<1	<1	<1
9/11/2012	<1	<1	<1	<1	<1	<1

4.3 Conclusions

- The smaller particle size of the soil resulted in early compaction within the soil columns preventing equal water seepage through the columns in comparison to the compost columns.
- The increased outflow of water through the compost columns may have impacted the higher loss of nutrients within column effluent.
- Bacterial pathogens, *Salmonella*, *Campylobacter*, and *E. coli*, were not detected in the compost. The initial *E. coli* levels were higher in ground soil in comparison to compost material.
- No *E. coli* was detected and recovered post seven days of *E. coli* inoculation. The compost did not incubate and increase the survivability of *E. coli*.

5. PLANT VIGOR EVALUAION

The physical, chemical, and biological benefits of using compost as mulch, soil amendment, or as a potting media have been well documented. Compost in general contains a full spectrum of primary and secondary nutrients; Total nitrogen (N), phosphorus (P) and potassium (K) are the three primary nutrients. The secondary nutrients are magnesium (Mg) and calcium (Ca). These are essential plant nutrients and also helps bind clusters of soil particles. This contributes to improved soil structure by providing small air channels and pores that hold air, moisture and nutrients (Wang *et al*. 2009). Compost provides essential nutrients for plant growth and can be a cofactor for several important enzyme activities. Nutrients such as calcium are an essential part of plant cell wall structure and must be present for the formation of new cells. The macro and micronutrients are often absent or present at lower levels in the common ground soil or synthetic fertilizers. Compost can also hold nutrients tight enough to prevent them from washing out, and loose enough so plants can take them up as needed. The compost can also help buffer the soil and neutralize both alkaline and acid soils, bringing pH levels to the optimum range for nutrient availability to plants (Wang *et al*. 2009).

5.1 Procedure

A. A field and a greenhouse study was conducted to evaluate plant growth, nutrient and metals uptake, soil test, health, and yield by three different plant species from June to September on a compost amended soil compared against a control (no treatment – soil alone). The greenhouse space for the control portion of the study was provided by the University of Wisconsin Oshkosh. The Outagamie County Brewster Village garden had provided approximately 25 feet wide by 200 feet long community garden plot for the field study experiment (Figure 5.1).

B. A total of three plant species used were used.

a. Fresh market vegetable plant (tomato plant, *Solanum lycopersicum*)
b. Ornamental flowering plant (*Lobelia cardinalis*)
c. Agronomic plant (the common oat, *Avena sativa*).

The tomato plants and the oat plants were only grown in the community garden plot. They were analyzed and grown in compost amended soil against soil provided in the garden plot (Figure 5.2). Only the flowering plants were grown and compared to the control by the means of greenhouse and community garden plot settings using compost amended soil compared against control (soil provided in the garden plot).

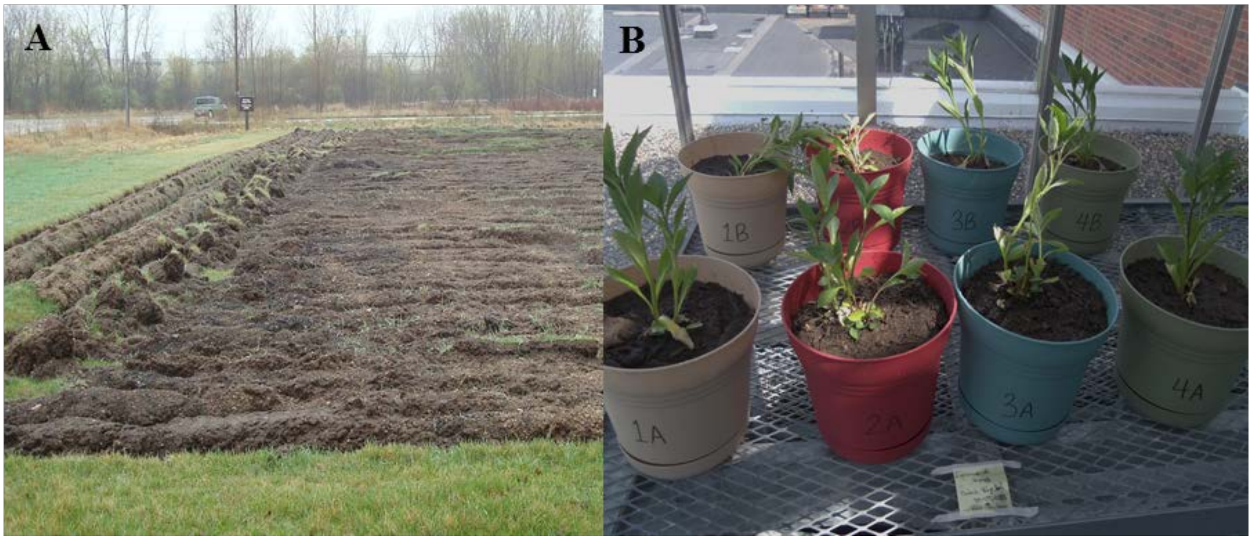


Figure 5.1: **A)** Outagamie County Brewster Village garden plot and **B)** University of Wisconsin Oshkosh greenhouse was utilized to evaluate the plant species used in the plant vigor evaluation.

C. Experimental design: Outagamie county Brewster Street Garden Plot.

A total of six experimental designs were evaluated in the community garden plot in soil alone and compost amended soil plots (Figure 5.2).

a. Tomato plants (*Solanum lycopersicum*) – soil plot
b. Tomato plants (*Solanum lycopersicum*) – compost amended soil plot
c. *Lobelia cardinalis* (flowering plant) – soil plot
d. *Lobelia cardinalis* (flowering plant) – compost amended soil plot
e. Oat plants *(Avena sativa)* - soil plot
f. Oat plants (*Avena sativa)* - compost amended soil plot

1. Eight of each plant (clones) species were grown in soil plot and compost amended soil plot in the community garden plot. Size of each of the plot was six feet wide by 14 feet long. The plot spaces needed for the experiment were rototilled and 12-15 CBF (cubic feet) of compost was mixed in three of the plots (plots two, four, and six) (Figure 5.2).

2. Every week all eight plant clones for each experimental design were analyzed for stem height, number of flowers and fruits if present. The total number of flowers and fruits were continually counted and the stem height was measured for 11 weeks. Each plant was watered twice a week (approximately half to one gallon)

3. End of the study (11 weeks), 25 random tomatoes from each of the eight clones were weighed. The tomatoes grown in soil plot were compared against compost amended soil plot tomatoes.

4. End of the study (11 weeks) the plant tissues (leaves, flowers and fruit) from each experimental design were analyzed for metal and nutrient uptake. Tissue analysis was conducted to evaluate the nutrient levels of plants in order to measure nutrient deficiencies, heavy metal uptake, and total mineral uptake. The tissue samples for the tomato plants were collected from the leaves and tomatoes grown in soil plot and compost amended soil plot. The leaves and the tomatoes were collected from all eight tomato plants. The tissue samples for the flowering plants were collected from the leaves and the flowers. The samples were collected from the clones two, four, and seven to cover the entire bases of each plot.

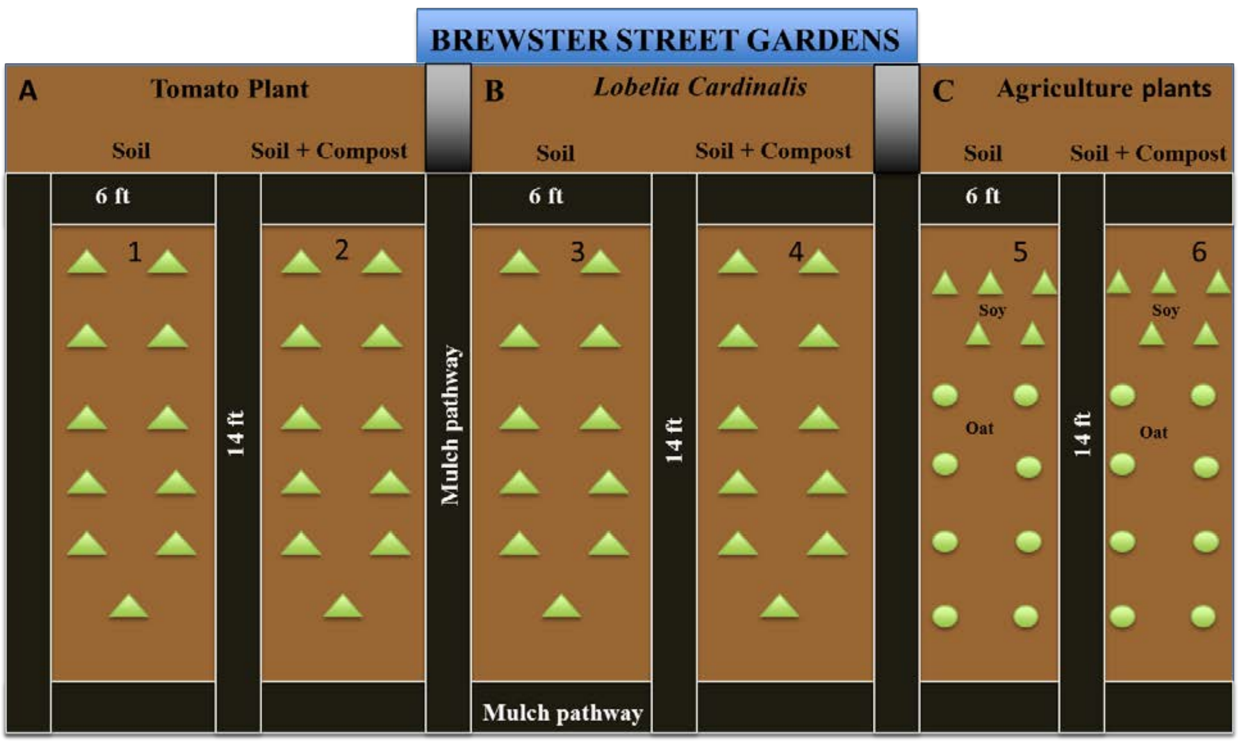


Figure 5.2: Outagamie County Brewster street plot layout. The three different plant species were grown in soil and compost amended soil. A total of eight plants for each plot were analyzed.

D. Experimental design: University of Wisconsin Oshkosh greenhouse.

A total of eight ornamental flowering plants (*Lobelia cardinalis*) were grown. A total of two experimental designs were evaluated.

a. *Lobelia cardinalis* (flowering plant) – soil pot
b. *Lobelia cardinalis* (flowering plant) – compost amended soil pot

1. Four clones of the flowering plants were grown in the green house in soil pots (1B-4B) and compost amended soil pots (1A-2A).
   a. In the 50:50 mixtures, a total of 4,000 g of soil and compost mixture was used.
   b. For soil alone, a total of 4,000 g of soil alone was used.

2. Every week all four plant clones for each experimental design were analyzed for stem height and number of flowers if present. The total number of flowers was continually counted and the stem height was measured for 12 weeks.

3. At the end of the study (12 weeks) the plant tissues (leaves and flowers) from each experimental design were analyzed for metal and nutrient uptake. The samples were collected from the clones 1B, 2B, 1A and 2A.

A. Analysis of plant tissue was conducted from the garden plot and greenhouse for the following samples from both soil and compost amended soil plots:
   a. Soil plot: leaves of tomato plant: composite samples (tomato plants: clones one through four)
   b. Soil plot: leaves of tomato plant: composite samples (tomato plants: clones five through eight)
   c. Soil plot: tomatoes: composite samples (tomato plants: clones one through four)
   d. Soil plot: tomatoes: composite samples (tomato plants: clones five through eight)
   e. Compost amended soil plot: leaves of Tomato plant: Composite samples (tomato plants: clones one through four)
   f. Compost amended soil plot: leaves of tomato plant: composite samples (tomato plants: clones five through eight)
   g. Compost amended soil plot: tomatoes: composite samples (tomato plants: clones one through four)
   h. Compost amended soil plot: tomatoes: composite samples (tomato plants: clones five through eight)
   i. Garden soil plot: leaves of *Lobelia cardinalis*: composite samples (clones two, four, and seven)
   j. Garden soil plot: flowers of *Lobelia cardinalis*: composite samples (clones two, four, and seven)

k. Garden compost amended soil plot: leaves of *Lobelia cardinalis*: composite samples (clones three, five, and seven)
l. Garden compost amended soil plot: flowers of *Lobelia cardinalis*: composite samples (clones three, five, and seven)
m. Greenhouse soil pot: leaves of *Lobelia cardinalis*: composite samples (clones 1B-2B)
n. Greenhouse soil pot: flowers of *Lobelia cardinalis*: composite samples (clones 1B-2B)
o. Greenhouse compost amended soil pot: leaves of *Lobelia cardinalis*: composite samples (clones 1A and 2A)
p. Greenhouse compost amended soil pot: flowers of *Lobelia cardinalis*: composite samples (clones 1A and 2A)

1. The elemental package – total minerals included: phosphorus (P), potassium (K), calcium (Ca), magnesium (Mg), sulfur (S), zinc (Zn), boron (B), manganese (Mn), iron (Fe), copper (Cu), aluminum (Al), sodium (Na), and total nitrogen (N).

2. The elemental package – heavy metals: cadmium (Cd), cobalt (Co), chromium (Cr), molybdenum (Mo), nickel (Ni), lead (Pb), lithium (Li), arsenic (As), selenium (Se), and barium (Ba)

5.2 Results and Discussion

The extensive plant vigor analysis was conducted in controlled (greenhouse) and uncontrolled (Outagamie County Brewster street plot) environments. The Brewster street garden plot was utilized to analyze a total of six experimental designs.

5.2.1 Outagamie county garden plot: Tomato plants (*Solanum lycopersicum*)

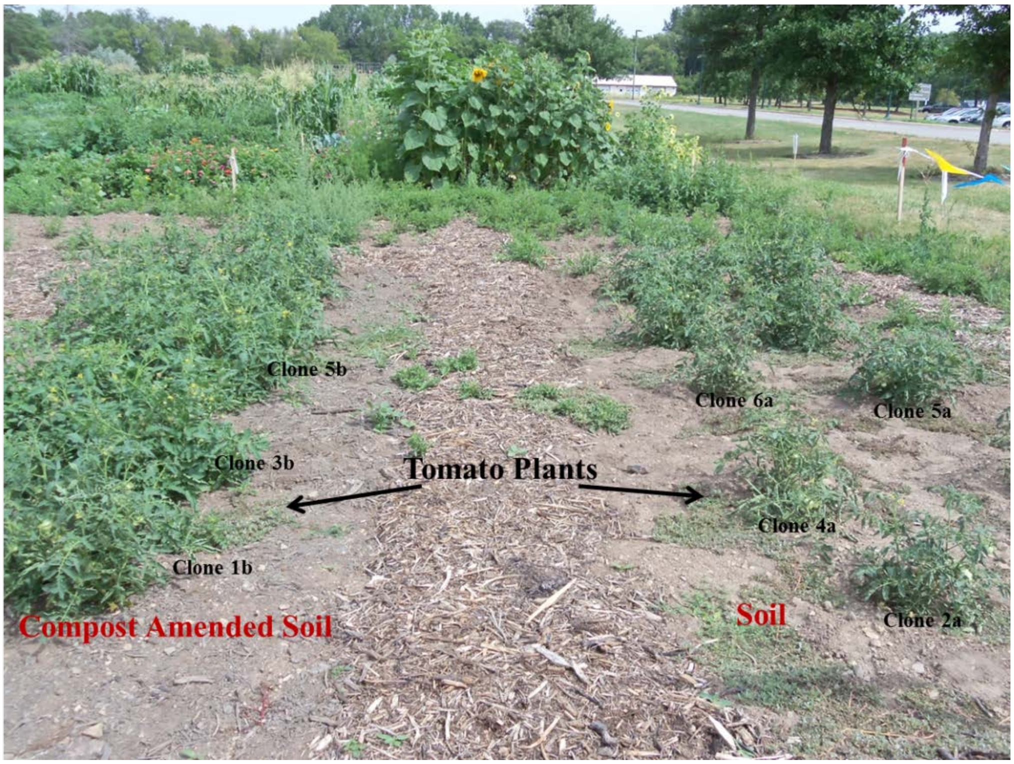


Figure 5.3: Garden plot view of soil (right) and compost amended soil plot (left)

Throughout the 11 week study the tomato plants grown in soil and compost amended soil plots were analyzed for stem height, number of flowers and number of fruits. At the conclusion of the study, all remaining fruits on the plants were harvested. Twenty five random tomatoes from each of the eight clones from both plots were weighed and compared.

Overall, the tomato plants grown in compost amended soil had a more positive impact on its growth and bulk of the plant (Figure 5.3). The stem height, numbers of flowers and fruit were similar up to first four weeks of the study. On average (n=8 clones), following 19 July until 27 August the clones grown in compost amended soil had increased stem height, number of flowers and number of fruits (Table 5). The number of flowers and fruits were doubled in comparison to the plants grown soil alone. The increased number of flowers translates to more fruits produced over the period of the study. The highest amount of flowers were detected on 8 August (n=8 clones, Soil plot = 25 & Compost amended soil = 64) (Figure 5.4). The amount of flowers in compost amended soil was three times higher than tomato plants grown in soil alone. The flowers stopped producing after 15 August and no flowers were counted in the last two weeks of the study. The highest amount of tomatoes grown were detected on 27 August (n=8 clones, soil plot = 40 & compost amended soil = 80) (Figure 5.4).

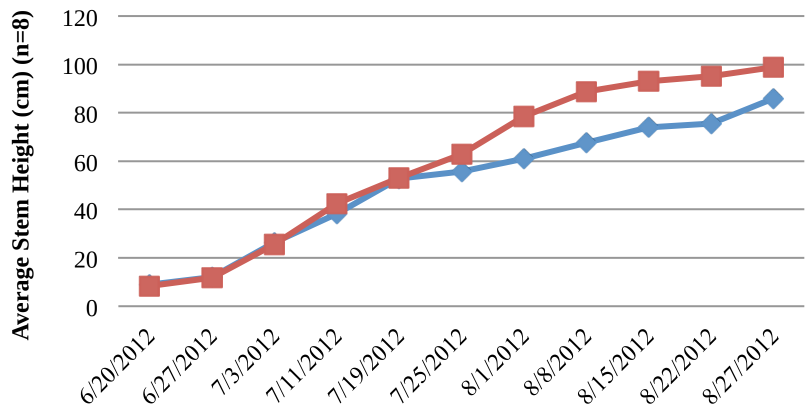
The number of fruits that grew in compost amended soil were two times higher than soil alone. The fruits that grew in compost amended soil also had higher mass and bulk in comparison to soil alone (Figure 5.5). This was true for all clones that were analyzed. The result demonstrates the overall benefits of the compost and the increased macro and micronutrients present within.

The tissues of the fruits and the leaves of the tomato plants were further analyzed at the conclusion of the study. The tissues of the tomato plants grown in soil and compost amended soil were compared. This is essential to make sure heavy metals and hazardous elements are not absorbed into the plant tissues and fruits that may be consumed. Overall, no substantial differences were detected between the two plots. Barium (Ba) was the only heavy metal that was detected at higher levels (leaves, soil = 28.85 ppm and compost amended soil = 43.95 ppm). However, it was detected at <1 ppm in the tomatoes. Barium is found in most soils at concentrations ranging from about 15 to 3,500 ppm and average values ranging between 265 and 835 ppm, depending on soil type (U.S. Department of Health and Human Services - ATSDR). Taking ATSDR Barium ranges into account, levels detected in tissues of leaves were very low and in fruits even lower. The other heavy metals detected within the tissues of leaves and fruits were < 3 ppm (Table 5.3). The concentration of heavy metals detected within the tissues of leaves and fruits were significantly low. This further helps assure the safety of the compost in gardening or agriculture.

Table 5.1: Tomato plants were grown in outside garden plot was analyzed in soil and compost amended soil plot. The summary is an average of eight clones for each plot after 11 weeks (except flowers per plant / nine weeks of data) in the garden plot. The analysis demonstrates average stem height, number of flowers per plant and number of fruit per plant (n =8).

	Soil	**Compost Amended Soil**
Average stem height (cm) (n=8)	85.8	98.8
Average number of flowers (n=8)	13	41
Average number of fruit (n=8)	40	80
Average weight of 25 fruit (g) (n=8)	2,961.1	3,784.8

A.



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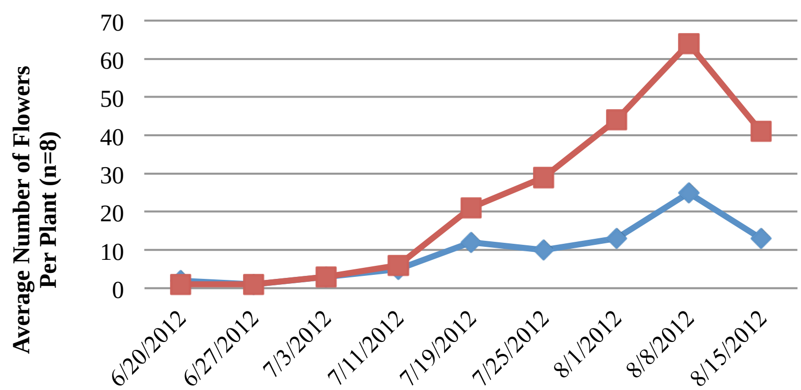


C.

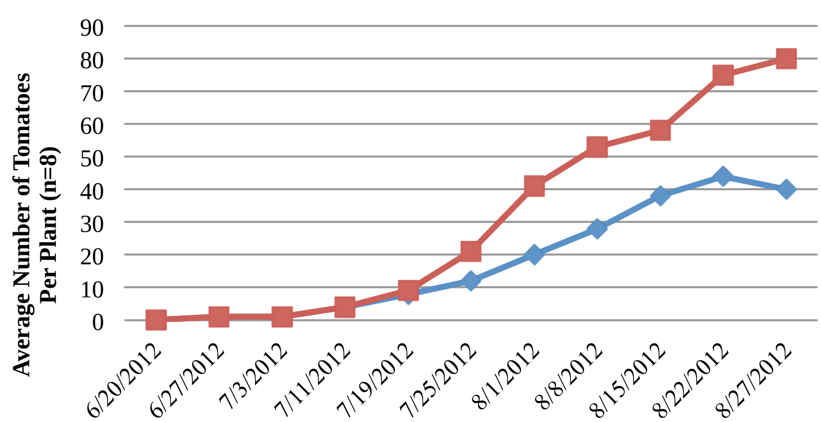


Figure 5.4: Average of eight tomato plants grown in garden plot in soil (Blue line) and compost amended soil (Red line) after 11 weeks (except for flowers per plant / nine weeks of data). The analysis demonstrates average **A)** Average stem height **B)** Average number of flowers per plant and **C)** Average number of tomatoes per plant (n =8) for each week.

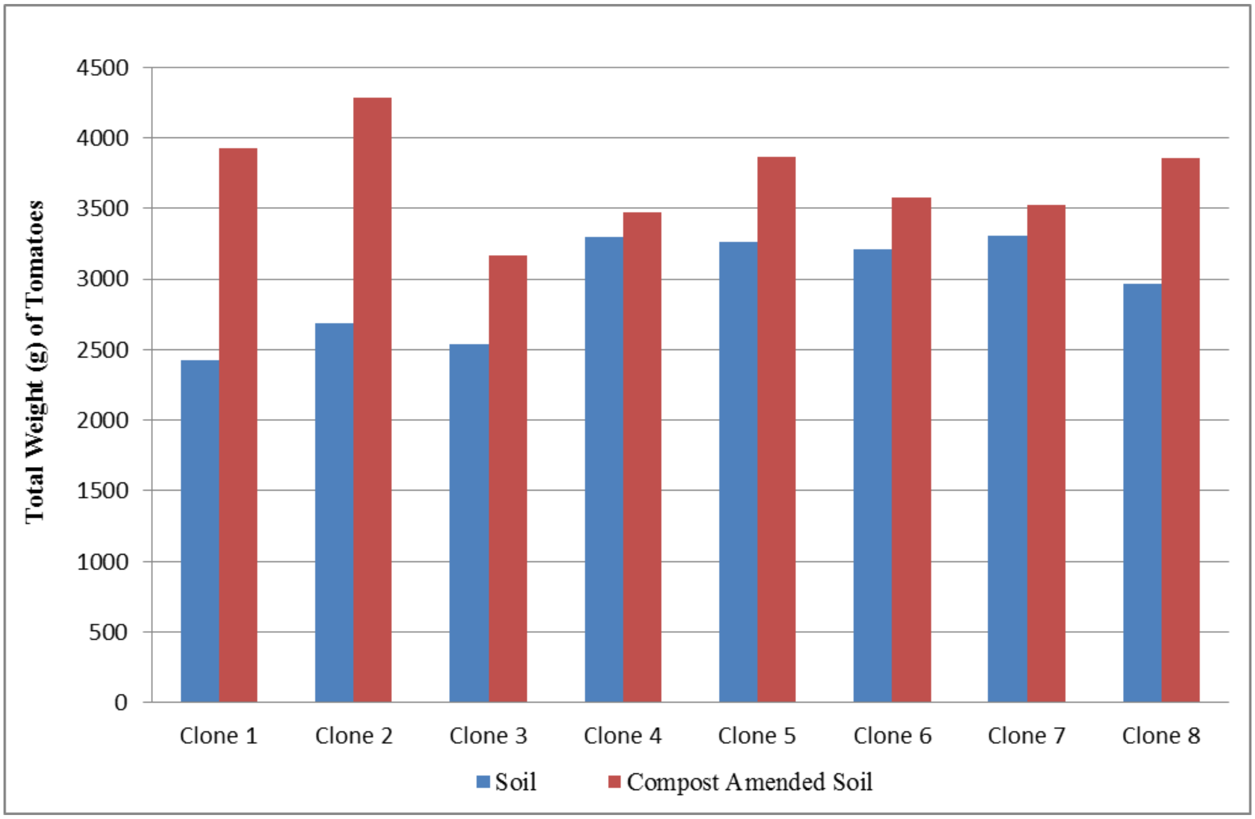


Figure 5.5: Total weight of 25 random tomatoes from each of the eight clones in soil and compost amended soil plots.

Table 5.2: Average total minerals within the tissues of leaves and fruits of tomato plants grown in soil and compost amended soil plot.

	Soil Plot		Compost Amended Soil Plot	
Total Minerals (ppm)	**Leaves (n=2)**	**Tomatoes (n=2)**	**Leaves (n=2)**	**Tomatoes (n=2)**
Aluminum (Al)	109.75	8.18	49.43	<5
Boron (B)	13.19	6.92	19.75	6.37
Calcium (Ca)	3,2250	1,950	39,700	1,500
Copper (Cu)	9.00	4.39	8.07	6.14
Iron (Fe)	312.95	46.50	173.90	47.65
Magnesium (Mg)	8,850	1,450	9,050	1,700
Manganese (Mn)	23.02	4.96	16.39	6.53
Phosphorus (P)	2,550	2,900	2,900	4,300
Potassium (K)	17,650	28,550	18,500	38,450
Sodium (Na)	247.05	148.65	266.10	189.9
Sulfur (S)	14,200	1,700	20,350	1,900
Total Nitrogen (Total N)	35,000	23,350	34,050	27,000
Zinc (Zn)	14.40	10.69	24.55	14.39

Table 5.3: Average heavy metals within the tissues of leaves and fruits of tomato plants grown in soil and compost amended soil plot.

	Soil Plot		Compost Amended Soil Plot	
Heavy Metals (ppm)	**Leaves (n=2)**	**Tomatoes (n=2)**	**Leaves (n=2)**	**Tomatoes (n=2)**
Arsenic (As)	<3	<3	<3	<3
Barium (Ba)	28.85	0.6	43.95	<0.02
Cadmium (Cd)	1.025	<0.4	0.89	<0.4
Cobalt (Co)	<0.3	<0.3	0.35	<0.3
Chromium (Cr)	<0.1	0.14	<0.1	<0.1
Lithium (Li)	0.4	0.065	0.48	<0.05
Molybdenum (Mo)	0.585	<0.4	1.49	<0.4
Nickel (Ni)	0.33	<0.3	<0.3	<0.3
Lead (Pb)	<2	<2	<2	<2
Selenium (Se)	<3	<3	<3	<3

5.2.2 Outagamie county garden plot: *Lobelia cardinalis*

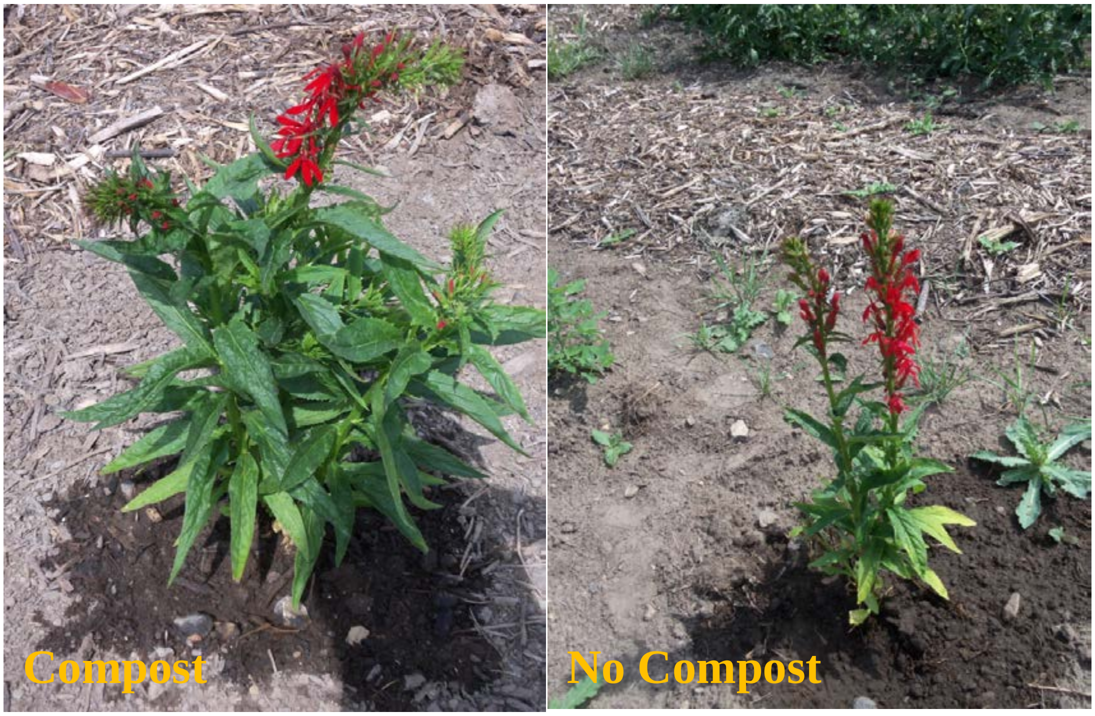


Figure 5.6: Garden plot view of soil plot (Right) and compost amended soil (left)

Throughout the 11 week study the flowering plants (*Lobelia cardinalis*) grown in soil and compost amended soil plots were analyzed for stem height and number of flowers.

The *Lobelia cardinalis* grown in compost amended soil had greater impact (higher stem height and number of flowers) on the overall plant growth. On average (n=8 clones), following 19 July until 27 August the clones grown in compost amended soil had greater stem height and number of flowers (Figure 5.7). The highest amount of flowers were detected on 27August (n=8 clones, soil plot = 94 and compost amended soil = 122) (Figure 5.7).

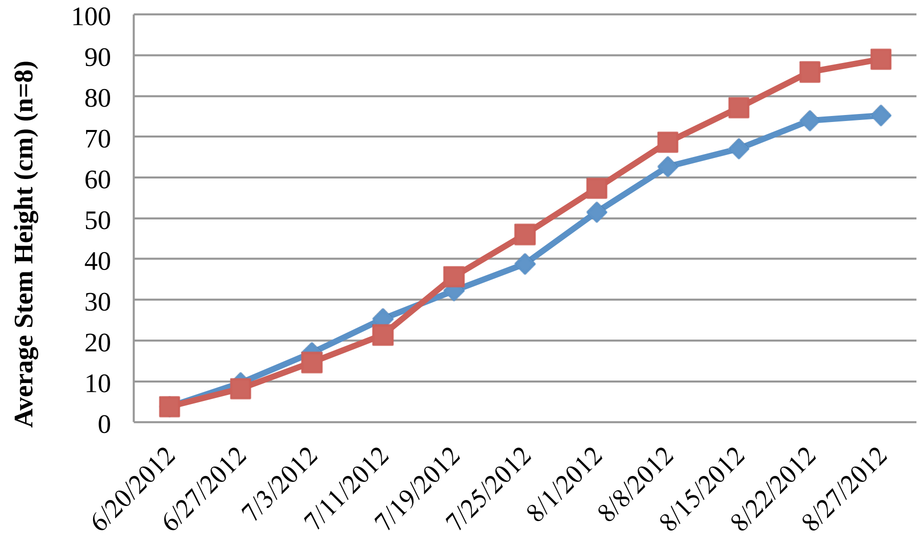
Overall, the compost amended soil had increased plant vigor in comparison to soil alone. However, it was not as significant as the effect on tomato plants. While the tomato plants can survive in the rigid environment the *Lobelia cardinalis* requires part sun to part shade and rich moist soil. The garden plot is located in an open field with no shade. The temperature between 20 June and 25 July were as high as 91^{o}F and the rainfall total was only 0.81 inches. These conditions may have impacted the full development of the plants. However, the compost demonstrated its moisture retention capabilities and the plants grown in a compost amended soil out performed those grown in soil alone. Moisture retention proved to be a beneficial quality throughout the study due to above average temperatures and lack of precipitation throughout the growing season. The increased moisture retention gives the plants greater chances of survival in hotter temperatures and when access to water is limited.

The tissues of the leaves and the flowers of the plants were further analyzed at the conclusion of the study. The tissues of the plants grown in soil and compost amended soil were compared. This is essential to make sure no heavy metals and hazardous elements are absorbed into the plant tissues. Overall, no substantial differences in heavy metals were detected between the two plots. Just like tissues analysis of tomato plants, barium (Ba) was the only heavy metal that was detected at higher levels (leaves, soil = 25.1 ppm & compost amended soil = 31.9 ppm). Within the flowers, barium was detected at 9.24 ppm (soil) and 5.1 ppm (compost amended soil). The other heavy metals detected within the tissues of leaves and flowers were < 3 ppm (Table 5.6).

Table 5.4: *Lobelia cardinalis* were grown in outside garden plots and were analyzed in soil and compost amended soil plot. The summary is an average of eight clones for each plot after 11 weeks in the garden plot. The analysis demonstrates average stem height and number of flowers per plant (n =8).

	Average Stem Height (cm) (n=8)	**Average Number of Flowers Per Plant (n=8)**
Soil	75.2	94
Compost Amended Soil	89.1	122

A.



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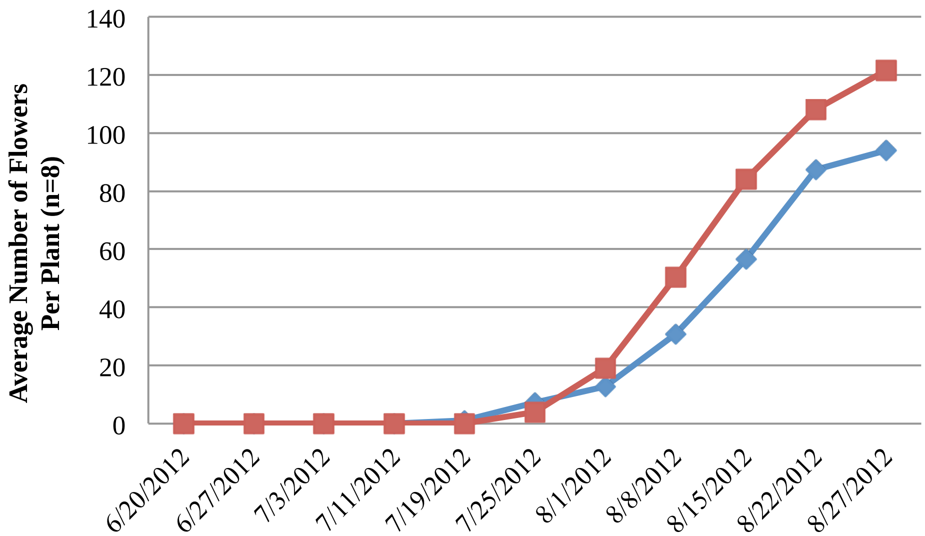


Figure 5.7: Average of eight clones grown in the garden plot in soil (Blue line) and compost amended soil (Red line) after 11 weeks. The analysis demonstrates average **A)** Average stem height and **B)** Average number of flowers per plant (n =8) for each week.

Table 5.5: Total minerals within the tissues of leaves and flowers of *Lobelia cardinalis* grown in soil and compost amended soil plot.

	Soil Plot		Compost Amended Soil Plot	
Total Minerals (ppm)	**Leaves**	**Flowers**	**Leaves**	**Flowers**
Aluminum (Al)	168.63	71.13	98.61	<5
Boron (B)	7.34	10.22	8.9	9.04
Calcium (Ca)	13,300	5,100	13,800	4,000
Copper (Cu)	3.76	5.86	3.17	5.77
Iron (Fe)	403.4	202.6	291.2	70.9
Magnesium (Mg)	4,500	2,000	4,100	1,700
Manganese (Mn)	21.39	13.49	24.7	10.48
Phosphorus (P)	2,200	2,900	2,000	2,800
Potassium (K)	14,700	10,700	17,600	10,900
Sodium (Na)	25.3	35.5	35.8	30
Sulfur (S)	3,000	2,000	3,200	1,600
Total Nitrogen (Total N)	34,500	23,000	32,100	22,300
Zinc (Zn)	19.21	20.72	14.46	19.73

Table 5.6: Heavy metals within the tissues of leaves and flowers of *Lobelia cardinalis* grown in soil and compost amended soil plot.

	Soil Plot		Compost Amended Soil Plot	
Heavy Metals (ppm)	**Leaves**	**Flowers**	**Leaves**	**Flowers**
Arsenic (As)	<3	<3	<3	<3
Barium (Ba)	25.1	9.24	31.78	5.07
Cadmium (Cd)	<0.4	<0.4	<0.4	<0.4
Cobalt (Co)	0.38	<0.3	<0.3	<0.3
Chromium (Cr)	<0.1	<0.1	<0.1	<0.1
Lithium (Li)	0.23	0.07	0.29	0.16
Molybdenum (Mo)	<0.4	<0.4	<0.4	<0.4
Nickel (Ni)	<0.3	0.91	<0.3	1.08
Lead (Pb)	<2	<2	<2	<2
Selenium (Se)	<3	<3	<3	<3

5.2.3 Greenhouse experiment: *Lobelia cardinalis*

Figure 5.8: *Lobelia cardinalis* visual comparison in soil pots (1B-4B) and compost amended soil pots (1A-2A) for four total clones.

The control, greenhouse experiment, was conducted for a total of 12 weeks. The flowering plants (*Lobelia cardinalis*) grown in soil (1B-4B) and compost amended soil (1A-4A) pots were analyzed for stem height and number of flowers that grew overtime.

The *Lobelia cardinalis* grown in compost amended soil had greater impact on the overall plant growth (Figure 5.8). On average (n=4 clones), there was an exponential increase in the stem height and number of flowers between 15 August until 11 September (Figure 5.9). The clones grown in compost amended soil had greater stem height and number of flowers (Figure 5.9). The highest amount of flowers were detected on 11 September (n=4 clones, Soil plot = 10 & Compost amended soil = 31). The stem height and the number of flowers per clone and average in the garden plot were significantly higher than the greenhouse (Figure 5.8 & 5.9).

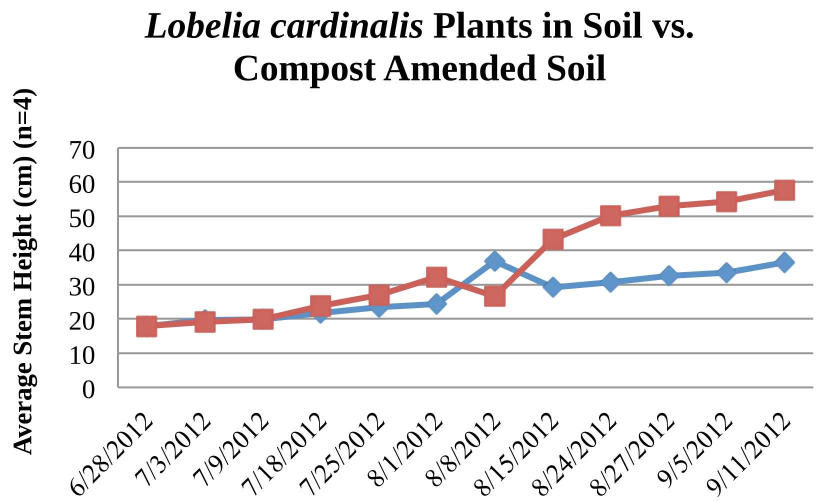
Overall, plant health in the compost amended soil exceeded those grown in soil alone. However, it was not as substantial as the *Lobelia cardinalis* plants grown in the garden plot. The outside plot provides a natural environment with constant flow/presence of essential elements, sun and even additional water on rain events; this essentially had a greater impact on the *Lobelia cardinalis* grew outside. In the garden plot and greenhouse, *Lobelia cardinalis* that were grown in the compost amended soil had a significant impact on the plants growth in comparison to the plants solely grown in the soil.

Plant leaf and flower tissues were further analyzed at the conclusion of the study. The tissues of the plants grown in soil and compost amended soil were compared. Just like tissues analysis of *Lobelia cardinalis* grown in the garden plot, barium (Ba) was the only heavy metal that was detected at higher levels (leaves, soil = 85.13 ppm and compost amended soil = 6.27 ppm) (Table 5.9). Within the flowers, barium was detected at 31.89 ppm (soil) and 18.68 ppm (compost amended soil). The concentration of Arsenic in tissues of flowers were detected at <9 ppm in soil pots, but only at <3 ppm at compost amended soil pots (Table 5.9). This further helps assure the environmental safety of the compost in gardening and agriculture settings.

Table 5.7: *Lobelia cardinalis* were grown in greenhouse and were analyzed in soil and compost amended soil. The summary is an average of four clones for each plot after 12 weeks in the green house. The analysis demonstrates average stem height and number of flowers per plant (n =4).

	Average Stem Height (cm) (n=4)	**Average Number of Flowers Per Plant (n=4)**
Soil	36.6	10
Compost Amended Soil	57.7	31

A.



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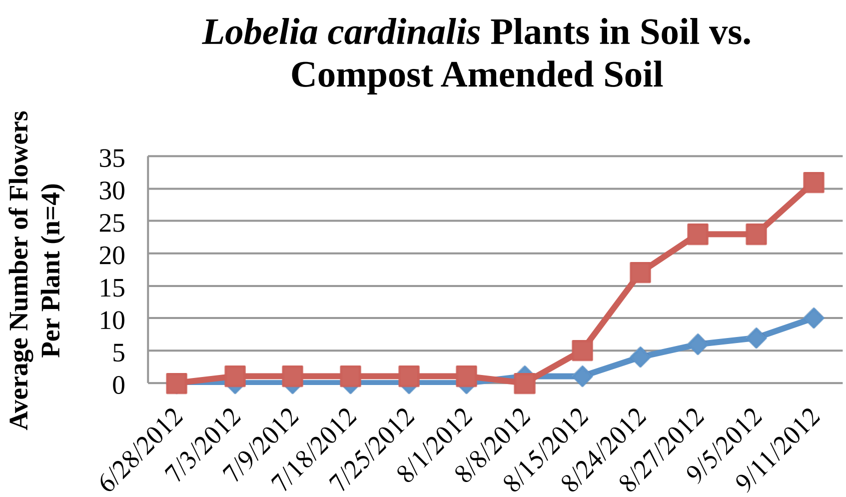


Figure 5.9: The graph illustrates average of four clones grown in greenhouse in soil (Blue line) and compost amended soil (Red line) after 12 weeks. The analysis demonstrates average **A)** Stem height and **B)** Number of flowers per plant (n =4) for each week.

Table 5.8: Total minerals within the tissues of flowers and leaves of *Lobelia cardinalis* grown in the greenhouse.

	Soil Plot		Compost Amended Soil Plot	
Total Mineral (ppm)	**Leaves**	**Flowers**	**Leaves**	**Flowers**
Aluminum (Al)	68.41	<16	<5	<5
Boron (B)	18.12	14.19	19.71	41.11
Calcium (Ca)	19,200	7,900	5,300	10,600
Copper (Cu)	6.13	2.96	11.95	3.8
Iron (Fe)	194.8	58.8	45	65
Magnesium (Mg)	6,300	2,300	3,200	5,800
Manganese (Mn)	31.92	16.65	16.37	28.44
Phosphorus (P)	1,900	3,100	3,600	3,600
Potassium (K)	19,900	18,000	20,800	32,000
Sodium (Na)	58.4	80.1	23.3	49.1
Sulfur (S)	2,200	2,100	2,500	3,300
Total Nitrogen (Total N)	34,400	26,100	23,200	31,900
Zinc (Zn)	33.23	29.89	37.54	45.4

Table 5.9: Heavy metal within the tissues of flowers and leaves of *Lobelia cardinalis* grown in the greenhouse.

	Soil Plot		Compost Amended Soil Plot	
Heavy Metals (ppm)	**Leaves**	**Flowers**	**Leaves**	**Flowers**
Arsenic (As)	<3	<9	<3	<3
Barium (Ba)	85.13	31.89	6.27	18.68
Cadmium (Cd)	<0.4	<1	<0.4	<0.4
Cobalt (Co)	<0.3	<0.9	<0.3	<0.3
Chromium (Cr)	<0.1	1.26	<0.1	<0.1
Lithium (Li)	0.36	0.62	0.1	0.36
Molybdenum (Mo)	<0.4	<1	<0.1	<0.1
Nickel (Ni)	0.58	1.2	1.51	<0.3
Lead (Pb)	<2	<6	<2	<2
Selenium (Se)	<3	<9	<3	<3

5.2.4 Outagamie County garden plot: Oat Plants *(Avena sativa)*

The oat plants (*Avena sativa*) were analyzed for a total of six weeks. Within week three, two of the clones were lost due to deficient or inadequate soil moisture levels (0.81 inches of rain) and high sustained temperatures (up to 91°F). Therefore, analysis for those two clones was not included in the final report. The other six clones started drying out around week seven. Thus, for oat plants the study was concluded after six weeks. Throughout the six week study the oats grown in soil and compost amended soil plots were analyzed for stem height and number of oats that grew per clone.

The oat plants grown in compost amended soil had greater impact on the overall plant growth (Figure 5.11). On average (n=6 clones), from 27 June until 11 July the clones grown in compost amended soil had greater stem height and number of oats (Figure 5.11). The highest amount of oats in soil and compost amended soil plots were detected on 11 July (n=6 clones, Soil plot = 10 & Compost amended soil = 24) (Table 5.10). There was a drop off in the oat production per each plant the following week (19 July).

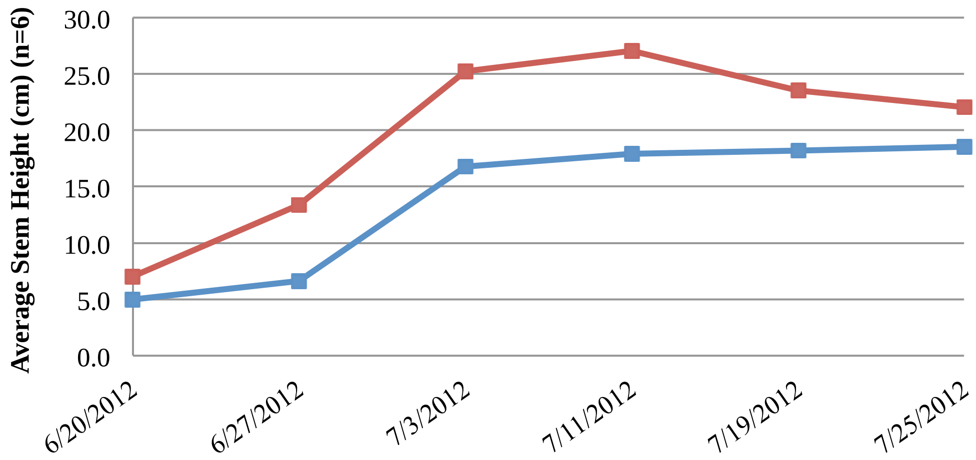
Tissue analysis was not conducted because the oat plants had dried out by week seven. Conclusions could not be made on the loss of the oats because both soil and compost amended soil oats had dried out by week seven.

Figure 5.10: Oat plants visual comparison in soil pots and compost amended soil pots.

Table 5.10: Oat plants *(Avena sativa)* were grown in outside garden plot and were analyzed in soil and compost amended soil plot. The summary is an average of six clones for each plot after four weeks in the garden plot. The analysis demonstrates average stem height and number of flowers per plant (n =6).

	Average Stem Height (cm) (n=6)	**Average Number of Oats Per Plant (n=6)**
Soil	17.9	10
Compost Amended Soil	27.1	24

A.



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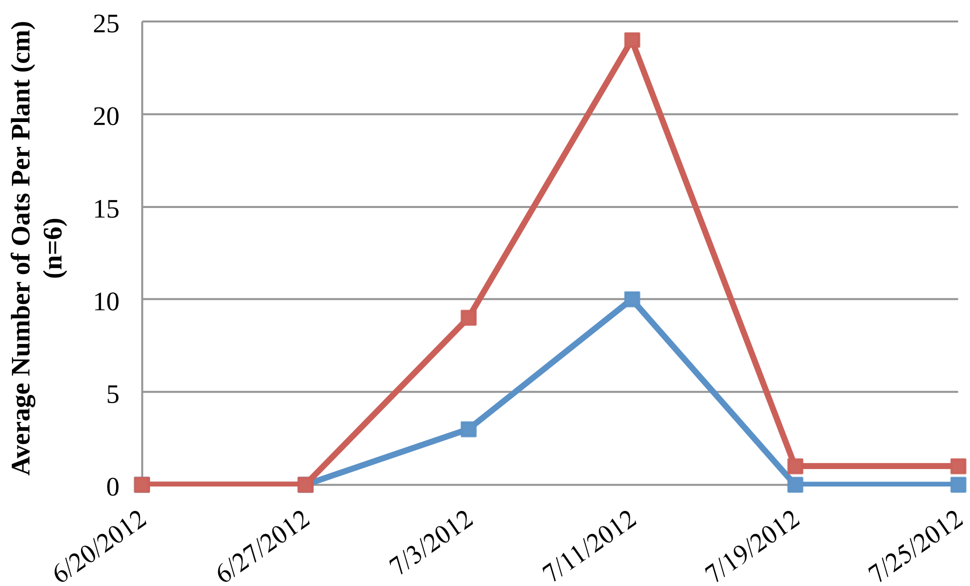

Figure 5.11: Average of the six oat plants grown in the garden plot in soil (Blue line) and compost amended soil (Red line) after five weeks. The analysis demonstrates average **A)** Stem height and **B)** Number of oats per plant (n =6) for each week.

5.3 Conclusions

- Overall, within the garden plot all plant species performed better (increased stem height and greater number of flowers and fruits) in compost amended soil in comparison to soil alone.
    - The increased flowers in tomato plants led to increased number of fruits.
    - The overall average mass of tomatoes grown in compost amended soil was higher than soil alone.
- In the controlled greenhouse study the *Lobelia cardinalis* yield response (increased stem height and greater number of flowers) in compost amended soil was greater than that of soil alone.
- Metals were detected at relatively low levels within tissues of the plants analyzed from soil and compost amends soil grown plants (garden plots and greenhouse).
- There was no major difference in mineral levels within tissues of the plants analyzed from soil and compost amends soil grown plants (garden plot and greenhouse).

6. GENERAL STUDY CONCLUSIONS

- This study was a successful overall investigation into the composition and possible end-use of Appleton compost. However, as has been previously discussed in this report there are a number of additional research questions that could be investigated. These are not necessarily essential, but would elucidate specific answers to questions that were beyond the scope of this project and may be of use to the City of Appleton as they look for additional markets and uses for this material.
- The nutrient levels (N, P, K, Mg, and Ca) in the compost (screened and unscreened) were 2-10 times higher in comparison to the garden plot soil.
- The results for metals analysis were below the US Composting Council (USCC) general ranges and NR 502.12(16) Class A compost specifications.
- The Coliform bacteria detected were below the USCC general range and NR 502.12(16) Class A compost specifications for the Appleton compost material.
- The pathogenic organisms *E. coli*, *Campylobacter*, and *Salmonella* were not detected in the Appleton compost material. Similar trends were observed from the bank stabilization and laboratory scale/soil column study.
- Based on the results from this study the Appleton compost material did not have an impact on the prevention of erosion. On average it appears that more overall negative erosion occurred from the compost plots vs. the non-compost plots, however it is unclear what exactly caused this (plot one: -1.1 cm and plot two: -1.56 cm vs. plot three: -0.09 cm, plot four: -0.59 cm, and plot five: 0.41 cm). It is recommended that an additional laboratory study should be conducted to evaluate and/or validate under controlled conditions the negative erosion, which was observed in the landfill demonstration.
- The Appleton compost material was not suitable for application in erosion socks due to the lack in structure and small particle size of the finished compost material. Changes to the compost recipe would be necessary if it would be desired to use the material in this type of application.
- The Appleton compost material performed very well in the soil amendment and grass establishment portions of this study and further applications in these areas should be pursued.
- Within this study all plant species performed better (increased stem height and greater number of flowers and tomatoes) in compost amended soil in comparison to soil alone.

Future Work

- Statistical analyses could be conducted to evaluate correlations between multiple parameters (e.g. nutrient loss vs. erosion) through linear regression and multi-variant statistics. In addition, general statistics including analysis of variance (ANOVA) and t-test to determine statistical differences could be evaluated.
- Development of supporting marketing materials (e.g. brochures and publications) could be generated through further collaboration with UW Oshkosh.
- Additional laboratory services could be provided for further development and evaluation of the compost material.

7. APPENDIX

7.1 Physical, Chemical, and Biological Data

- Official ERIC lab reports supplied electronically

7.2 Pilot Scale Material Demonstration

Plot one (Compost with Erosion socks): Raw Data

Plot 1 Calcium, total recoverable as Ca by ICP, mg/kg WWB	**Section 1**	**Section 2**	**Section 3**	**Section 4**	**Section 5**
9/25/2012	86,000	91,000	110,000	110,000	120,000
10/2/2012	120,000	120,000	110,000	NA	NA
10/9/2012	130,000	99,000	99,000	NA	NA
10/19/2012	88,000	100,000	110,000	81,000	NA
10/22/2012	86,000	100,000	110,000	100,000	NA
10/30/2012	84,000	110,000	110,000	92,000	NA
11/6/2012	100,000	100,000	110,000	NA	NA
11/13/2012	110,000	76,000	82,000	NA	NA
Average:	100,500	99,500	105,125	95,750	

Plot 1 Magnesium, total recoverable as Mg by ICP, mg/kg WWB	**Section 1**	**Section 2**	**Section 3**	**Section 4**	**Section 5**
9/25/2012	24,000	26,000	37,000	22,000	27,000
10/2/2012	26,000	23,000	31,000	NA	NA
10/9/2012	52,000	25,000	16,000	NA	NA
10/19/2012	18,000	35,000	38,000	21,000	NA
10/22/2012	18,000	30,000	26,000	33,000	NA
10/30/2012	15,000	27,000	33,000	23,000	NA
11/6/2012	23,000	20,000	23,000	NA	NA
11/13/2012	37,000	12,000	13,000	NA	NA
Average:	26,625	24,750	27,125	24,750	

Plot 1 Nitrogen, total Kjeldahl as N on solids, mg/kg WWB	Section 1	Section 2	Section 3	Section 4	Section 5
9/25/2012	5,000	4,600	7,600	6,400	7,100
10/2/2012	6,700	6,400	6,300	NA	NA
10/9/2012	6,700	6,800	5,800	NA	NA
10/19/2012	5,900	4,000	5,600	5,200	NA
10/22/2012	5,900	6,500	6,800	5,700	NA
10/30/2012	6,100	5,000	5,000	6,100	NA
11/6/2012	5,600	5,600	7,100	NA	NA
11/13/2012	4,800	5,700	6,200	NA	NA
Average:	5,838	5,575	6,300	5,850	

Plot 1 Potassium, total recoverable as K by ICP, mg/kg WWB	Section 1	Section 2	Section 3	Section 4	Section 5
9/25/2012	3,600	2,700	1,900	1,900	1,900
10/2/2012	2,100	2,100	2,000	NA	NA
10/9/2012	1,600	2,300	2,000	NA	NA
10/19/2012	1,200	900	1,300	1,900	NA
10/22/2012	850	1,600	1,100	890	NA
10/30/2012	1,000	1,100	830	770	NA
11/6/2012	2,500	1,500	1,300	NA	NA
11/13/2012	1,000	890	1,300	NA	NA
Average:	1,731	1,636	1,466	1,365	

Plot 1 Phosphorus (mg P/L)	Section 1	Section 2	Section 3	Section 4	Section 5
9/25/2012	522.13	359.17	388.28	427.04	372.79
10/2/2012	459.19	358.5	331.02	NA	NA
10/9/2012	32.73	48.69	18.29	NA	NA
10/19/2012	27.4	21.75	19.06	16.19	NA
10/22/2012	8.89	14.37	21.63	96.76	NA
10/30/2012	81.4	21.96	134.51	111.78	NA
11/6/2012	133.95	124.83	137.46	NA	NA
11/13/2012	474.82	359.69	531.99	NA	NA
Average:	218	164	198	163	

E. coli MPN/g

Plot 1 *E. coli* MPN/g	Section 1	Section 2	Section 3	Section 4
9/27/12	0.4	38.4	47.92	1.24
10/4/12	174.08	967.84	0	NA
10/10/12	2.08	1.64	1.64	NA
10/23/12	9.52	6.92	9.72	1.64
10/24/12	0.4	0	392.16	22.4
10/31/12	2.52	4.36	111.12	3.36
11/7/12	0.8	1.2	7.4	NA
11/14/12	0.4	0	0.4	NA
Average	23.8	145.8	81.4	7.2

Physical Erosion Overtime

Plot 1 Erosion (cm)	Section 1	Section 2	Section 3	Section 4
10/9/12	-0.5	0	-1	-1.25
10/19/12	-0.5	-0.7	-1.5	0.75
10/23/12	0.75	-0.7	1.5	0.25
10/30/12	0	-0.375	-3	0
11/6/12	-1.25	0.125	0	-0.25
11/13/12	1.75	0.5	3	0.5
11/20/12	-0.625	-0.375	-0.5	-0.25
11/28/12	0.125	0.375	-1.5	0.25

Plot two (Compost without Erosion socks): Raw Data

Plot 2 Calcium, total recoverable as Ca by ICP, mg/kg WWB	**Section 1**	**Section 2**	**Section 3**	**Section 4**	**Section 5**
9/25/2012	93,000	100,000	120,000	140,000	130,000
10/2/2012	120,000	120,000	110,000	NA	NA
10/9/2012	130,000	100,000	120,000	NA	NA
10/19/2012	100,000	92,000	100,000	64,000	NA
10/22/2012	110,000	99,000	96,000	100,000	NA
10/30/2012	93,000	98,000	100,000	110,000	NA
11/7/2012	110,000	110,000	99,000	NA	NA
11/13/2012	83,000	76,000	92,000	NA	NA
Average:	104,875	99,375	104,625	103,500	

Plot 2 Magnesium, total recoverable as Mg by ICP, mg/kg WWB	**Section 1**	**Section 2**	**Section 3**	**Section 4**	**Section 5**
9/25/2012	25,000	32,000	36,000	54,000	45,000
10/2/2012	27,000	36,000	18,000	NA	NA
10/9/2012	45,000	23,000	51,000	NA	NA
10/19/2012	29,000	12,000	29,000	13,000	NA
10/22/2012	29,000	18,000	17,000	19,000	NA
10/30/2012	27,000	22,000	20,000	16,000	NA
11/7/2012	28,000	22,000	22,000	NA	NA
11/13/2012	13,000	17,000	15,000	NA	NA
Average:	27,875	22,750	26,000	25,500	

Plot 2 Nitrogen, total Kjeldahl as N on solids, mg/kg WWB	Section 1	Section 2	Section 3	Section 4	Section 5
9/25/2012	3,200	1,900	6,500	6,700	5,900
10/2/2012	6,800	7,200	7,000	NA	NA
10/9/2012	7,500	6,000	4,500	NA	NA
10/19/2012	6,800	6,400	5,700	6,300	NA
10/22/2012	6,100	5,100	6,500	6,700	NA
10/30/2012	6,300	6,200	6,100	3,900	NA
11/7/2012	5,800	5,700	280	NA	NA
11/13/2012	4,400	5,200	4,600	NA	NA
Average:	5,863	5,463	5,148	5,900	

Plot 2 Potassium, total recoverable as K by ICP, mg/kg WWB	Section 1	Section 2	Section 3	Section 4	Section 5
9/25/2012	2,700	2,400	1,900	1,500	1,900
10/2/2012	2,600	1,900	2,400	NA	NA
10/9/2012	1,700	1,900	1,900	NA	NA
10/19/2012	1,200	1,200	1,200	950	NA
10/22/2012	1,200	1,100	1,100	1,000	NA
10/30/2012	1,900	1,300	1,100	1,100	NA
11/7/2012	1,200	1,300	1,600	NA	NA
11/13/2012	1,200	2,700	1,100	NA	NA
Average:	1,713	1,725	1,538	1,138	

Phosphorus (mg P/L)	Section 1	Section 2	Section 3	Section 4	Section 5
9/25/2012	727.15	775.59	643.07	705.82	776.5
10/2/2012	428.13	312.55	458.78	NA	NA
10/9/2012	32.39	8.83	25.02	NA	NA
10/19/2012	33.39	25.47	52.18	20.34	NA
10/22/2012	24.43	31.92	98.99	24.04	NA
10/30/2012	4.17	38.29	53.39	1.83	NA
11/6/2012	215.43	129.28	105.87	NA	NA
11/13/2012	425.42	465.31	415.95	NA	NA
Average:	236	223	232	188	

E. coli MPN/g

Plot 2 *E. coli* MPN/g	Section 1	Section 2	Section 3	Section 4
9/27/12	0	1.64	0	8.72
10/4/12	1.24	0.4	0	NA
10/10/12	2.52	2.92	1.24	NA
10/23/12	0	4.32	1.64	3.92
10/24/12	0.8	0	17.64	1.64
10/31/12	0.8	1.24	1.2	2.08
11/7/12	7.88	2.96	44.48	NA
11/14/12	0.4	9.12	5.92	NA
Average	1.7	1.9	9.5	4.1

Physical Erosion Over Time

Plot 2 Erosion (cm)	Section 1	Section 2	Section 3	Section 4
10/9/12	0	-0.625	-3	-0.5
10/19/12	-0.95	-0.625	0	-0.6
10/23/12	-0.15	-1	-1	-3.4
10/30/12	-0.55	-0.625	-1	1.5
11/6/12	0.15	0.125	1.75	-0.5
11/13/12	1.25	1.375	0.75	2
11/20/12	-1	-0.375	-0.5	-0.75
11/28/12	-0.25	-0.75	3	0

Plot three (Bare Soil without Erosion socks): Raw Data

Plot 3 Calcium, total recoverable as Ca by ICP, mg/kg WWB	**Section 1**	**Section 2**	**Section 3**	**Section 4**	**Section 5**
9/25/2012	57,000	50,000	43,000	47,000	50,000
10/2/2012	130,000	93,000	100,000	NA	NA
10/9/2012	58,000	46,000	37,000	NA	NA
10/19/2012	46,000	47,000	37,000	39,000	NA
10/22/2012	53,000	31,000	36,000	51,000	NA
10/30/2012	67,000	40,000	44,000	43,000	NA
11/7/2012	55,000	38,000	42,000	NA	NA
11/13/2012	33,000	42,000	40,000	NA	NA
Average:	62,375	48,375	47,375	45,000	

Plot 3 Magnesium, total recoverable as Mg by ICP, mg/kg WWB	**Section 1**	**Section 2**	**Section 3**	**Section 4**	**Section 5**
9/25/2012	27,000	25000	26,000	26,000	27,000
10/2/2012	48,000	21,000	31,000	NA	NA
10/9/2012	24,000	24,000	23,000	NA	NA
10/19/2012	21,000	22,000	21,000	22,000	NA
10/22/2012	22,000	18,000	22,000	23,000	NA
10/30/2012	24,000	23,000	23,000	21,000	NA
11/7/2012	24,000	23,000	21,000	NA	NA
11/13/2012	21,000	21,000	20,000	NA	NA
Average:	26,375	22,125	23,375	23,000	

Plot 3 Nitrogen, total Kjeldahl as N on solids, mg/kg WWB	Section 1	Section 2	Section 3	Section 4	Section 5
9/25/2012	550	1,000	590	440	490
10/2/2012	6,700	3,400	4,900	NA	NA
10/9/2012	380	430	420	NA	NA
10/19/2012	320	220	600	370	NA
10/22/2012	710	530	510	600	NA
10/30/2012	260	270	230	330	NA
11/7/2012	410	390	220	NA	NA
11/13/2012	310	350	340	NA	NA
Average:	1,205	824	976	435	

Plot 3 Potassium, total recoverable as K by ICP, mg/kg WWB	Section 1	Section 2	Section 3	Section 4	Section 5
9/25/2012	3,400	3,900	4,200	3,900	3,400
10/2/2012	1,500	2,300	2,600	NA	NA
10/9/2012	2,300	3,300	3,700	NA	NA
10/19/2012	2,900	2,700	3,600	3,600	NA
10/22/2012	2,800	2,800	3,600	2,600	NA
10/30/2012	2,600	4,100	3,800	3,400	NA
11/7/2012	3,700	5,000	4,500	NA	NA
11/13/2012	4,700	3,600	3,900	NA	NA
Average:	2,988	3,463	3,738	3,375	

Plot 3 Phosphorus (mg P/L)	Section 1	Section 2	Section 3	Section 4	Section 5
9/25/2012	1,115.47	1,861.05	1,786.42	4,413.63	1,760.46
10/2/2012	421.18	92.71	80.39	NA	NA
10/9/2012	5.29	5.81	4.18	NA	NA
10/19/2012	ND	2.29	22.97	ND	NA
10/22/2012	54.88	71.23	68.71	13.23	NA
10/30/2012	2.54	5.46	1.51	0.77	NA
11/6/2012	26.26	1.55	2.4	NA	NA
11/13/2012	1.48	2.19	6.86	NA	NA
Average:	232	255	247	1476	

E. coli MPN/g

Plot 3 ***E. coli*** **MPN/g**	**Section 1**	**Section 2**	**Section 3**	**Section 4**
9/27/12	0	0.4	0	2.08
10/4/12	0	0	0	NA
10/10/12	0	0	0	NA
10/23/12	0	0	0.8	0.8
10/24/12	0	0	38.32	1.24
10/31/12	0.4	2.08	2.48	1.24
11/7/12	0	1.2	0	NA
11/14/12	0	0	0	NA
Average	0.1	0.5	5.9	1.3

Physical Erosion Overtime

Plot 3 Erosion (cm)	**Section 1**	**Section 2**	**Section 3**	**Section 4**
10/9/12	-0.125	0	-0.25	0
10/19/12	0.125	-0.75	0.5	-0.5
10/23/12	0	-0.375	-0.25	0.25
10/30/12	-0.125	0.875	0	0.25
11/6/12	-0.125	-0.625	0	0
11/13/12	0.25	0.75	0	0
11/20/12	0	0.125	0	0
11/28/12	0	-0.375	0	0

Plot four (Bare soil with Erosion socks): Raw Data

Plot 4 Calcium, total recoverable as Ca by ICP, mg/kg WWB	Section 1	Section 2	Section 3	Section 4	Section 5
9/25/2012	60,000	51,000	57,000	46,000	48,000
10/2/2012	45,000	58,000	52,000	NA	NA
10/9/2012	61,000	52,000	40000	NA	NA
10/19/2012	56,000	38,000	42,000	41,000	NA
10/22/2012	54,000	52,000	39,000	35,000	NA
10/30/2012	61,000	55,000	48,000	42,000	NA
11/7/2012	60,000	54,000	38,000	NA	NA
11/13/2012	50,000	50,000	47,000	NA	NA
Average:	55,875	51,250	45,375	41,000	

Plot 4 Magnesium, total recoverable as Mg by ICP, mg/kg WWB	Section 1	Section 2	Section 3	Section 4	Section 5
9/25/2012	23,000	25,000	29,000	26,000	26,000
10/2/2012	25,000	27,000	26,000	NA	NA
10/9/2012	25000	24,000	24,000	NA	NA
10/19/2012	23,000	23,000	22,000	22,000	NA
10/22/2012	24,000	23,000	22,000	22,000	NA
10/30/2012	24,000	23,000	26,000	23,000	NA
11/7/2012	24,000	24,000	21,000	NA	NA
11/13/2012	21,000	22,000	21,000	NA	NA
Average:	23,625	23,875	23,875	23,250	

Plot 4 Nitrogen, total Kjeldahl as N on solids, mg/kg WWB	Section 1	Section 2	Section 3	Section 4	Section 5
9/25/2012	260	350	470	630	330
10/2/2012	580	790	340	NA	NA
10/9/2012	640	380	460	NA	NA
10/19/2012	330	320	330	390	NA
10/22/2012	360	300	430	330	NA
10/30/2012	340	320	460	510	NA
11/7/2012	230	250	400	NA	NA
11/13/2012	290	350	290	NA	NA
Average:	379	383	398	465	

Plot 4 Potassium, total recoverable as K by ICP, mg/kg WWB	Section 1	Section 2	Section 3	Section 4	Section 5
9/25/2012	2,200	3,000	2,700	3,600	3,400
10/2/2012	3,500	2,800	3,100	NA	NA
10/9/2012	2,100	2,600	3,700	NA	NA
10/19/2012	2,400	3,700	3,400	3,400	NA
10/22/2012	3,000	3,100	3,800	3,800	NA
10/30/2012	2,600	2,800	3,600	4,000	NA
11/7/2012	3,200	3,700	3,600	NA	NA
11/13/2012	2,700	2,800	2,900	NA	NA
Average:	2,713	3,063	3,350	3,700	

Plot 4 Phosphorus (mg P/L)	Section 1	Section 2	Section 3	Section 4	Section 5
9/25/2012	22.78	0.92	2.72	0.9	3.66
10/2/2012	807.4	1,172.12	1,228.56	NA	NA
10/9/2012	0.88	6.03	10.21	NA	NA
10/19/2012	11.59	40.7	17.82	6.94	NA
10/22/2012	6.89	15.38	73.38	97.47	NA
10/30/2012	ND	ND	3.14	ND	NA
11/6/2012	24.54	12.08	5.67	NA	NA
11/13/2012	7.21	4.08	12.02	NA	NA
Average:	126	179	169	35	

E. coli MPN/g

Plot 4 ***E. coli*** **MPN/g**	**Section 1**	**Section 2**	**Section 3**	**Section 4**
9/27/12	0	0	0	5.36
10/4/12	5.84	0	1.2	NA
10/10/12	0.8	0	0	NA
10/23/12	0	0.4	0.8	0.4
10/24/12	0	0	0	8.72
10/31/12	0	9.72	1.2	6.32
11/7/12	0	21.16	0	NA
11/14/12	0	0.8	0	NA
Average	0.8	4.5	0.5	5.2

Physical Erosion Overtime

Plot 4 Erosion (cm)	**Section 1**	**Section 2**	**Section 3**	**Section 4**
10/9/12	0	-0.25	0	-2
10/19/12	0	0	-2	0
10/23/12	-0.125	-0.125	2.25	0.5
10/30/12	0.125	0	-0.75	0.5
11/6/12	0	-0.375	-1.5	-0.75
11/13/12	0	0.125	1.5	0.25
11/20/12	-0.125	0	0	0
11/28/12	-0.125	0	0	0.5

Plot five (PAM-12 Plus with Erosion socks): Raw Data

Plot 5 Calcium, total recoverable as Ca by ICP, mg/kg WWB	**Section 1**	**Section 2**	**Section 3**	**Section 4**	**Section 5**
9/25/2012	42,000	52,000	51,000	53,000	51,000
10/2/2012	62,000	63,000	50,000	NA	NA
10/9/2012	57,000	87,000	42,000	NA	NA
10/19/2012	60,000	35,000	34,000	40,000	NA
10/22/2012	56,000	37,000	36,000	42,000	NA
10/30/2012	60,000	46,000	47,000	44,000	NA
11/7/2012	59,000	43,000	37,000	NA	NA
11/13/2012	43,000	39,000	35,000	NA	NA
Average:	54,875	50,250	41,500	44,750	

Plot 5 Magnesium, total recoverable as Mg by ICP, mg/kg WWB	**Section 1**	**Section 2**	**Section 3**	**Section 4**	**Section 5**
9/25/2012	16,000	24,000	25,000	22,000	26,000
10/2/2012	24,000	26,000	26,000	NA	NA
10/9/2012	24,000	43,000	22,000	NA	NA
10/19/2012	25,000	22,000	20,000	21,000	NA
10/22/2012	22,000	21,000	20,000	22,000	NA
10/30/2012	22,000	22,000	21,000	21,000	NA
11/7/2012	24,000	24,000	20,000	NA	NA
11/13/2012	21,000	19,000	18,000	NA	NA
Average:	22,250	25,125	21,500	21,500	

Plot 5 Nitrogen, total Kjeldahl as N on solids, mg/kg WWB	Section 1	Section 2	Section 3	Section 4	Section 5
9/25/2012	570	930	910	1,100	830
10/2/2012	1,000	590	600	NA	NA
10/9/2012	830	910	560	NA	NA
10/19/2012	550	660	340	400	NA
10/22/2012	760	510	840	560	NA
10/30/2012	530	420	410	340	NA
11/7/2012	370	480	270	NA	NA
11/13/2012	750	470	290	NA	NA
Average:	670	621	528	600	

Plot 5 Potassium, total recoverable as K by ICP, mg/kg WWB	Section 1	Section 2	Section 3	Section 4	Section 5
9/25/2012	2,000	2,800	3,500	3,000	3,600
10/2/2012	3,100	2,700	3,600	NA	NA
10/9/2012	2,800	6,100	2,900	NA	NA
10/19/2012	2,600	4,000	4,300	3,700	NA
10/22/2012	2,600	3,600	3,300	2,900	NA
10/30/2012	3,200	3,800	3,400	3,500	NA
11/7/2012	3,600	4,600	3,800	NA	NA
11/13/2012	3,800	3,900	3,000	NA	NA
Average:	2,963	3,938	3,475	3,275	

Plot 5 Phosphorus (mg P/L)	Section 1	Section 2	Section 3	Section 4	Section 5
9/25/2012					
10/2/2012	2,894.41	1,309.03	1,696.49	NA	NA
10/9/2012	9.43	10.62	ND	NA	NA
10/19/2012	26.97	ND	21.22	1.55	NA
10/22/2012	ND	ND	0	ND	NA
10/30/2012	2.56	2.43	9.34	3.92	NA
11/7/2012	71.3	66.18	19.02	NA	NA
11/13/2012	191.33	79.84	60.95	NA	NA
Average:	533	294	301	3	

E. coli MPN/g

Plot 5 ***E. coli*** **MPN/g**	**Section 1**	**Section 2**	**Section 3**	**Section 4**
9/27/12	0	1.24	0.8	2.08
10/4/12	0	0	2.08	NA
10/10/12	1.24	9.24	0	NA
10/23/12	0	0.8	3	0
10/24/12	0.8	0.8	0	0.8
10/31/12	0	1.64	418.48	1.64
11/7/12	0	2.52	0	NA
11/14/12	0.8	0	0	NA
Average	0.4	2.3	60.6	1.1

Physical Erosion Overtime

Plot 5 Erosion (cm)	**Section 1**	**Section 2**	**Section 3**	**Section 4**
10/9/12	0.125	-0.25	-0.5	-0.5
10/19/12	-0.375	0.25	1	1
10/23/12	0.125	-0.5	-0.5	-0.5
10/30/12	0.375	0.875	0	0.25
11/6/12	-0.5	-0.25	0	-0.25
11/13/12	0.5	0	0.25	0.5
11/20/12	-0.125	-0.25	0.25	0.5
11/28/12	-0.125	0	0.5	-0.25

7.3 Nutrient Loss at a Laboratory Scale

Calcium, total recoverable as Ca by ICP (mg/Kg WWB)	Soil	Soil + Compost	Soil + Screened Compost	Compost	Compost + Screened Compost	Screened Compost
8/6/2012	860	1,100	770	990	880	740
8/13/2012	300	650	180	360	370	330
8/23/2012	130	130	180	170	200	150
9/4/2012	82	150	130	160	170	90
9/11/2012	75	160	100	110	86	82
Average:	289	438	272	358	341	278

Magnesium, total recoverable as Mg by ICP (mg/Kg WWB)	Soil	Soil + Compost	Soil + Screened Compost	Compost	Compost + Screened Compost	Screened Compost
8/6/2012	450	840	600	1,000	850	670
8/13/2012	160	570	150	430	410	320
8/23/2012	71	71	150	270	220	140
9/4/2012	41	15	110	210	180	85
9/11/2012	36	150	81	120	85	75
Average:	152	329	218	406	349	258

Nitrogen, total Kjeldahl as N on solids (mg/Kg WWB)	Soil	Soil + Compost	Soil + Screened Compost	Compost	Compost + Screened Compost	Screened Compost
8/6/2012	7.4	63	23	81	80	50
8/13/2012	15	50	27	73	72	59
8/23/2012	21	21	34	48	50	46
9/4/2012	29	39	37	39	48	49
9/11/2012	7.2	20	14	21	21	19
Average:	16	39	27	52	54	45

Potassium, total recoverable as K by ICP (mg/Kg WWB)	Soil	Soil + Compost	Soil + Screened Compost	Compost	Compost + Screened Compost	Screened Compost
8/6/2012	66	530	560	1,200	1,100	1,000
8/13/2012	42	480	180	620	660	600
8/23/2012	24	24	150	440	360	300
9/4/2012	15	150	120	290	300	170
9/11/2012	13	140	96	160	130	110
Average:	32	265	221	5,42	510	436

Total Phosphorus (P) (mg/L)	Soil	Soil + Compost	Soil + Screened Compost	Compost	Compost + Screened Compost	Screened Compost
8/6/2012	20.6	21.31	5.9	22.84	1.408	1.414
8/13/2012	1.04	3.99	3.33	15.09	8.32	6.94
9/4/2012	1.19	9.7	3.31	13.29	15.23	7.45
9/11/2012	1.21	8.58	10.3	21.2	9.23	8.67
Average:	6	11	6	18	9	6

7.4 Plant Vigor Evaluation

1. Tomato plants (Summary) for Compost Amended Soil and Soil and Plots

	Average Stem Height (cm) (n=8)		**Average Number of Flowers Per Plant (n=8)**		**Average Number of Tomatoes Per Plant (n=8)**	
Date	**Soil**	**Compost + Soil**	**Soil**	**Compost + Soil**	**Soil**	**Compost + Soil**
6/20/2012	8.9	8.2	2	1	0	0
6/27/2012	12.1	11.8	1	1	1	1
7/3/2012	26.2	25.4	3	3	1	1
7/11/2012	38.3	42.4	5	6	4	4
7/19/2012	52.9	53.2	12	21	8	9
7/25/2012	55.8	62.8	10	29	12	21
8/1/2012	61.1	78.5	13	44	20	41
8/8/2012	67.7	88.7	25	64	28	53
8/15/2012	74	93.1	13	41	38	58
8/22/2012	75.6	95.3	NA	NA	44	75
8/27/2012	85.79	98.8	NA	NA	40	80

1a. Raw Data: Tomato plant Grown in Compost Amended Soil and Soil Plots

Tomato Plant Stem Height (cm) in Compost Amended Soil Plot

Date	Clone 1b	Clone 2b	Clone 3b	Clone 4b	Clone 5b	Clone 6b	Clone 7b	Clone 8b	Average
6/20/2012	7	10	10	8	7.5	10	6	7	8.2
6/27/2012	10	14.1	13.2	13	12	12.8	8.5	10.8	11.8
7/3/2012	24.8	25.8	28	22.1	25.9	26.9	23.1	26.4	25.4
7/11/2012	39.9	41.7	43.3	42.6	42.9	43.3	41.7	43.7	42.4
7/19/2012	53.9	54.3	56.8	51.1	49.3	51.6	52.2	56.6	53.2
7/25/2012	57.4	59.9	63.4	61.1	66.7	60	66.7	67.2	62.8
8/1/2012	69.4	81.7	77	88	83.9	76	72.3	79.5	78.5
8/8/2012	72.5	87.9	79.3	91.9	100	96.4	88.9	92.9	88.7
8/15/2012	78.9	90.7	81.2	100.5	101.9	99.8	91.1	100.9	93.1
8/22/2012	81.2	100.5	82.5	107.4	105.7	101.1	93.2	90.5	95.3
8/27/2012	85.4	101.2	84.4	115.2	110.6	101.2	96.7	95.5	98.8

Tomato Plant Stem Height (cm) in Soil Plot

Date	Clone 1a	Clone 2a	Clone 3a	Clone 4a	Clone 5a	Clone 6a	Clone 7a	Clone 8a	Average
6/20/2012	10	9	8	10	10	9	8	7	8.9
6/27/2012	13.5	12.2	13.3	11	11.2	15.1	10	10.5	12.1
7/3/2012	24	26.9	26.6	28.4	27.1	26.8	26.9	23	26.2
7/11/2012	34.4	40.1	34.1	37.4	41.2	33.4	44	41.8	38.3
7/19/2012	42.6	53.4	52.1	54.2	52.6	46.9	62	59.2	52.9
7/25/2012	45.3	50.9	57.1	57.1	54.6	50.6	66.9	63.6	55.8
8/1/2012	52.6	54.3	54.2	61.9	57.5	55.1	72.8	80.4	61.1
8/8/2012	60.5	60.7	56.3	64.4	63.6	67.4	81.5	87.3	67.7
8/15/2012	65.3	68.7	60.8	72.5	69.9	71.7	90.5	92.4	74
8/22/2012	66.6	69.4	63	73.2	72.1	75.8	91.2	93.8	75.6
8/27/2012	85	73.8	80	89	85	80	93.5	100	85.79

Flowering Body per Tomato Plant in Compost Amended Soil Plot										
Date	**Clone 1b**	**Clone 2b**	**Clone 3b**	**Clone 4b**	**Clone 5b**	**Clone 6b**	**Clone 7b**	**Clone 8b**	**Total**	**Average**
6/20/2012	1	1	0	1	2	1	0	0	6	1
6/27/2012	0	0	3	0	0	0	0	0	3	1
7/3/2012	5	2	4	2	1	2	3	1	20	3
7/11/2012	7	5	9	4	5	5	5	6	46	6
7/19/2012	23	21	35	14	18	18	21	14	164	21
7/25/2012	9	22	64	29	24	24	25	31	228	29
8/1/2012	15	33	49	36	59	54	50	57	353	44
8/8/2012	54	64	37	54	83	73	59	85	509	64
8/15/2012	56	51	22	28	72	37	29	29	324	41

Flowering Body per Tomato Plant in Soil Plot										
Date	**Clone 1a**	**Clone 2a**	**Clone 3a**	**Clone 4a**	**Clone 5a**	**Clone 6a**	**Clone 7a**	**Clone 8a**	**Total**	**Average**
6/20/2012	1	2	3	1	3	2	2	1	15	2
6/27/2012	0	0	0	1	2	1	0	0	4	1
7/3/2012	4	2	2	2	5	2	2	2	21	3
7/11/2012	4	2	2	7	5	6	5	5	36	5
7/19/2012	2	8	13	9	14	9	15	25	95	12
7/25/2012	4	6	2	10	13	6	18	23	82	10
8/1/2012	3	5	3	12	11	5	36	30	105	13
8/8/2012	12	20	13	25	23	15	47	42	197	25
8/15/2012	12	20	1	11	11	11	6	31	103	13

Number of Fruits per Tomato Plant in Compost Amended Soil Plot										
Date	**Clone 1b**	**Clone 2b**	**Clone 3b**	**Clone 4b**	**Clone 5b**	**Clone 6b**	**Clone 7b**	**Clone 8b**	**Total**	**Average**
6/20/2012	0	0	0	0	0	0	0	0	0	0
6/27/2012	1	2	0	0	1	1	0	1	6	1
7/3/2012	1	2	2	1	1	1	0	1	9	1
7/11/2012	5	3	6	3	4	4	4	4	33	4
7/19/2012	12	10	12	8	6	12	7	8	75	9
7/25/2012	22	26	23	18	22	20	18	16	165	21
8/1/2012	35	29	49	37	36	38	55	47	326	41
8/8/2012	49	41	58	46	49	74	55	50	422	53
8/15/2012	44	46	73	44	85	48	72	51	463	58
8/22/2012	57	91	87	68	68	71	76	78	596	75
8/27/2012	63	110	80	67	102	75	88	58	643	80

Number of Fruits per Tomato Plant in Soil Plot										
Date	**Clone 1a**	**Clone 2a**	**Clone 3a**	**Clone 4a**	**Clone 5a**	**Clone 6a**	**Clone 7a**	**Clone 8a**	**Total**	**Average**
6/20/2012	0	0	0	0	0	0	0	0	0	0
6/27/2012	0	1	1	0	2	2	0	0	6	1
7/3/2012	1	1	2	0	3	3	1	0	11	1
7/11/2012	3	3	3	2	6	3	7	3	30	4
7/19/2012	3	6	5	6	14	6	11	13	64	8
7/25/2012	2	6	9	13	18	12	15	23	98	12
8/1/2012	8	8	13	17	25	13	32	44	160	20
8/8/2012	12	12	19	35	34	20	40	52	224	28
8/15/2012	14	27	34	34	46	23	66	57	301	38
8/22/2012	20	34	23	39	49	37	71	80	353	44
8/27/2012	23	25	29	33	45	37	53	71	316	40

2. *Lobelia cardinalis* (Summary) for Compost Amended Soil and Soil and Plots

	Average Stem Height (cm) (n=8)		Average Number of Flowers Per Plant (n=8)	
Date	**Soil**	**Compost Amended Soil**	**Soil**	**Compost Amended Soil**
6/20/2012	3.8	3.8	0	0
6/27/2012	9.6	8.2	0	0
7/3/2012	17	14.7	0	0
7/11/2012	25.3	21.4	0	0
7/19/2012	32.2	35.7	1.1	0
7/25/2012	38.8	46	7.3	4
8/1/2012	51.6	57.4	12.8	19.1
8/8/2012	62.6	68.6	30.7	50.5
8/15/2012	67.1	77.1	56.6	84.1
8/22/2012	74	85.9	87.3	108
8/27/2012	75.2	89.1	94.1	121.6

2a. Raw Data: *Lobelia cardinalis* Grown in Compost Amended Soil and Soil Plots

***Lobelia cardinalis* Stem Height (cm) in Compost Amended Soil Plot**									
Date	**Clone 1b**	**Clone 2b**	**Clone 3b**	**Clone 4b**	**Clone 5b**	**Clone 6b**	**Clone 7b**	**Clone 8b**	**Average**
6/20/2012	3	3.5	5.5	3.5	3.5	3.5	2.5	5.5	3.8
6/27/2012	5	7	13.2	7.2	8.1	8.5	6.2	10.5	8.2
7/3/2012	9.9	10.9	22.2	12.4	16	17.5	10.8	18.1	14.7
7/11/2012	12.9	12.7	32.6	19.9	24.9	23.2	17.2	28	21.4
7/19/2012	23.2	20.2	52.3	35.8	38.7	42	27.8	45.6	35.7
7/25/2012	32.8	28.4	63.1	48.4	45.2	52.2	39.9	58.2	46
8/1/2012	45.1	37.3	75.1	61.4	59.6	62	57.8	61.2	57.4
8/8/2012	56.5	49.5	87	N/A	73.3	69.9	71.2	73.2	68.6
8/15/2012	N/A	60.3	90.6	N/A	80.7	70.7	80.3	80	77.1
8/22/2012	N/A	73.2	97.3	N/A	89.8	77.2	90.3	88.1	85.9
8/27/2012	N/A	77.5	100	N/A	90.5	80	92	94.6	89.1

***Lobelia cardinalis* Stem Height (cm) in Soil Plot**									
Date	**Clone 1a**	**Clone 2a**	**Clone 3a**	**Clone 4a**	**Clone 5a**	**Clone 6a**	**Clone 7a**	**Clone 8a**	**Average**
6/20/2012	2.2	1.2	3.5	5.5	5.5	4.5	4	4	3.8
6/27/2012	4.5	3	11.5	16.5	11.2	10	8.2	12	9.6
7/3/2012	6.9	5.6	18.8	29.9	20.7	18.9	14.4	21.4	17
7/11/2012	11.2	8.8	24.9	46.7	28.1	30.5	21.1	31.2	25.3
7/19/2012	20.2	15.9	38.3	16	41.3	56.8	31.3	37.9	32.2
7/25/2012	22.4	23.3	45.9	22.2	48.9	60.5	39.7	47.7	38.8
8/1/2012	39.4	38.3	59.9	35.2	60.8	69.3	56.2	54.1	51.6
8/8/2012	49.7	49.4	60.9	N/A	72.9	81.8	65.1	58.5	62.6
8/15/2012	N/A	50.8	70.1	N/A	80.2	70.8	70.4	60.5	67.1
8/22/2012	N/A	59.6	75.2	N/A	84.2	81.2	76.1	67.7	74
8/27/2012	N/A	61.1	77.8	N/A	85.4	82.3	75.7	69.2	75.2

Flowering Body per *Lobelia cardinalis* Plant in Compost Amended Soil Plot										
Date	**Clone 1b**	**Clone 2b**	**Clone 3b**	**Clone 4b**	**Clone 5b**	**Clone 6b**	**Clone 7b**	**Clone 8b**	**Total**	**Average**
6/20/2012	0	0	0	0	0	0	0	0	0	0
6/27/2012	0	0	0	0	0	0	0	0	0	0
7/3/2012	0	0	0	0	0	0	0	0	0	0
7/11/2012	0	0	0	0	0	0	0	0	0	0
7/19/2012	0	0	0	0	0	0	0	0	0	0
7/25/2012	0	0	9	0	2	11	0	10	32	4
8/1/2012	0	0	40	15	37	40	0	21	153	19.1
8/8/2012	23	0	98	N/A	88	66	21	58	354	50.5
8/15/2012	N/A	3	79	N/A	162	127	79	55	505	84.1
8/22/2012	N/A	26	123	N/A	119	119	187	74	648	108
8/27/2012	N/A	38	130	N/A	138	121	169	134	730	121.6

Flowering Body per *Lobelia cardinalis* Plant in Soil Plot										
Date	**Clone 1a**	**Clone 2a**	**Clone 3a**	**Clone 4a**	**Clone 5a**	**Clone 6a**	**Clone 7a**	**Clone 8a**	**Total**	**Average**
6/20/2012	0	0	0	0	0	0	0	0	0	0
6/27/2012	0	0	0	0	0	0	0	0	0	0
7/3/2012	0	0	0	0	0	0	0	0	0	0
7/11/2012	0	0	0	0	0	0	0	0	0	0
7/19/2012	0	0	0	0	6	3	0	0	9	1.1
7/25/2012	0	0	0	0	16	24	0	19	59	7.3
8/1/2012	0	2	0	0	30	40	12	19	103	12.8
8/8/2012	13	17	2	N/A	43	54	65	21	215	30.7
8/15/2012	N/A	71	37	N/A	55	71	84	22	340	56.6
8/22/2012	N/A	84	64	N/A	70	111	172	23	524	87.3
8/27/2012	N/A	100	55	N/A	85	48	248	29	565	94.1

2b. Green House: *Lobelia cardinalis* (Summary) for Compost Amended Soil and Soil and Pots

	Average Stem Height (cm) (n=8)		Average Number of Flowers Per Plant (n=8)	
Date	**Soil**	**Compost Amended Soil**	**Soil**	**Compost Amended Soil**
6/28/2012	17.9	17.9	0	0
7/3/2012	19.6	19.2	0	1
7/9/2012	19.9	19.9	0	1
7/18/2012	21.8	23.8	0	1
7/25/2012	23.4	27	0	1
8/1/2012	24.4	32.3	0	1
8/8/2012	36.9	26.6	1	0
8/15/2012	29.3	43.2	1	5
8/24/2012	30.7	50.1	4	17
8/27/2012	32.5	53	6	23
9/5/2012	33.5	54.3	7	23
9/11/2012	36.6	57.7	10	31

2b. Green house: Raw Data: *Lobelia cardinalis* Grown in Compost Amended Soil and Soil Plots

Lobelia cardinalis **Stem Height (cm) in Compost Amended Soil Pots**					
Date	**Clone 1a**	**Clone 2a**	**Clone 3a**	**Clone 4a**	**Average**
6/28/2012	18	15.5	20.1	18	17.9
7/3/2012	19.1	16.4	22.5	19	19.2
7/9/2012	20.5	16.4	24.4	18.6	19.9
7/18/2012	27.9	19.2	26.8	21.3	23.8
7/25/2012	32.8	21.7	30.3	23.5	27
8/1/2012	39.4	27	36	26.9	32.3
8/8/2012	25.1	22.4	33.7	25.3	26.6
8/15/2012	53.5	35.3	46.5	37.6	43.2
8/24/2012	60.8	41.3	54.2	44.1	50.1
8/27/2012	65.3	46.1	54.2	46.6	53
9/5/2012	67.2	47.3	55.5	47.4	54.3
9/11/2012	70.9	51	55	54	57.7

Lobelia cardinalis **Stem Height (cm) in Soil Pots**					
Date	**Clone 1b**	**Clone 2b**	**Clone 3b**	**Clone 4b**	**Average**
6/28/2012	18.5	16.5	20.2	16.7	17.9
7/3/2012	20.5	18.1	20.9	19	19.6
7/9/2012	20.2	18.3	22.1	19.1	19.9
7/18/2012	21.1	19.2	27.2	19.9	21.8
7/25/2012	22.6	20.4	29.6	21.3	23.4
8/1/2012	23.1	20.2	31.2	23.2	24.4
8/8/2012	45.3	29.9	40.7	31.8	36.9
8/15/2012	27.8	24.4	36.5	28.8	29.3
8/24/2012	29.5	25.3	37.1	31.1	30.7
8/27/2012	30.5	26.2	39.4	33.9	32.5
9/5/2012	31	27.5	39.5	36	33.5
9/11/2012	34	30.9	42	39.5	36.6

Flowering Body per Plant in Compost Amended Soil Pots						
Date	Clone 1a	Clone 2a	Clone 3a	Clone 4a	Total	Average
6/28/2012	0	0	1	0	1	0
7/3/2012	0	0	2	0	2	1
7/9/2012	0	0	2	0	2	1
7/18/2012	0	0	2	0	2	1
7/25/2012	0	0	2	0	2	1
8/1/2012	0	0	2	0	2	1
8/8/2012	0	0	0	0	0	0
8/15/2012	9	0	9	0	18	5
8/24/2012	26	11	14	18	69	17
8/27/2012	31	22	17	20	90	23
9/5/2012	33	26	18	16	93	23
9/11/2012	32	27	41	22	122	31

Flowering Body per Plant in Soil Pots						
Date	Clone 1b	Clone 2b	Clone 3b	Clone 4b	Total	Average
6/28/2012	0	0	0	0	0	0
7/3/2012	0	0	0	0	0	0
7/9/2012	0	0	0	0	0	0
7/18/2012	0	0	0	0	0	0
7/25/2012	0	0	0	0	0	0
8/1/2012	0	0	0	0	0	0
8/8/2012	0	0	2	0	2	1
8/15/2012	0	0	3	0	3	1
8/24/2012	3	2	9	0	14	4
8/27/2012	6	4	10	4	24	6
9/5/2012	5	3	9	10	27	7
9/11/2012	6	8	9	15	38	10

8. REFERENCES

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