Carbon Dioxide Evolution of Soils

TAMU Study Abroad
Dominica 2002

By:
Jessica Casey

Submitted to:
Dr. Tom Lacher
Dr. Jim Woolley

Abstract

The purpose of this project is to determine the amount of carbon dioxide evolved in the different soils of Dominica. The objective of the study is to determine what differences are found among the soils in different habitats on Dominica including: primary rainforest, secondary rainforest, dry forest, and elfin forest.

Introduction

Soils on Dominica reflect the island's volcanic origins in the sense that they vary in the particular parent material weathered. On the upper slope of the island, shallow soils occur over volcanic material. However, on about 50% of the island, the soil is deep, strongly weathered allophonic (podzolic and latosolic) and kaolinitic clay soils which mean rich brown soil that settles into valleys (Evans and James, 1997). In all the other places on the island yellow and red soils occur, while in the interior of the island and on the Atlantic side the soils are clinging red clay. The montmorillonitic shoal clay soils occur on the leeward coastal side, and these soils are fine-textured, dark brown to grey. The youngest soils, kaolinitic soils, are the richest in nutrients, and usually occur on the southern part of the island, but the more mature yellow and red soils are more fertile where the forest resides.

Carbon dioxide levels provide a major factor for the determination of microbial activity in soil. Carbon compromises about 45-50% of the soils, and

when microorganisms metabolize, O_2 is consumed and CO_2 is evolved in the form of:

(CH2O)x +O2 > CO2 + H2O + intermediates + cell material + energy.

Due to the difference in habitats, four habitats were chosen to sample in the hope that different levels of CO_2 would occur. Primary rainforest of Middleham Falls, secondary rainforest at Springfield Plantation, dry forest at Cabrits National Park, and elfin forest at Freshwater Lake were the habitats sampled.

Materials

- Small Shovel
- Soil Samples (3 obtained from each area)
- Tupperware containers (substitute for 500 ml jars with lids)
- Glucose
- NaOH (1.0N)
- Balance
- HCl (1.0N)
- $BaCl_2$ (50% solution)
- Phenolphthalein
- Burette (10 ml used)
- 50 ml beakers
- Pipets (1.0 ml)

Methods

From each sample obtained in the field, I measured out two100 grams portions of each and placed the samples in two separate Tupperware containers. Three samples were thus obtained in each area of study. Add enough water (15-20 ml) to each sample to approximately 60% field capacity.

I left one of the samples unamended (nothing was added) and amended the other sample with glucose powder. I mixed the glucose into the soil and

place the lids on each of the containers. This step was followed with all 3 samples and the lids were placed on each of the containers (the number of containers for each sample area should be 6.)

To each container I added a 50 ml beaker with 1.0N NaOH and left it gently on the surface of the soil. I sealed the Tupperware containers tightly. To insure a good seal, I removed all soil from the rim of the Tupperware and then put the lids on.

Incubate the Tupperware containers at room temperature (this can be done also in an incubator at 30 degrees Celsius). After 24 hours I determined the amount of CO_2 evolved by the soil sample amended with the glucose and by the unamended soil.

To determine the amount of CO_2 produced in each sample, I took one sample at a time and carefully lifted out the beaker containing the alkali (NaOH). I added 2-3 drops of phenolphthalein and 1.0 ml of 50% $BaCl_2$ to the beaker to precipitate the carbonate as an insoluble barium carbonate and titrate the unneutralized alkali with 1.0N HCl. To titrate the solution, I added the HCl to the burette and place the solution underneath and begin the titration process. I had to titrate slowly and stir until the pink color (appears after the phenolphthalein is added) just disappears. The endpoint needed to be approached slowly and then I recorded the exact volume of acid required for the color and precipitate to dissolve.

To calculate the amount of CO_2 evolved I used the following equation: (B-V)NE.

Where:

V=volume of acid required to titrate the alkali with the amendment (glucose)

B=volume of acid required to titrate the alkali in the unamended soil

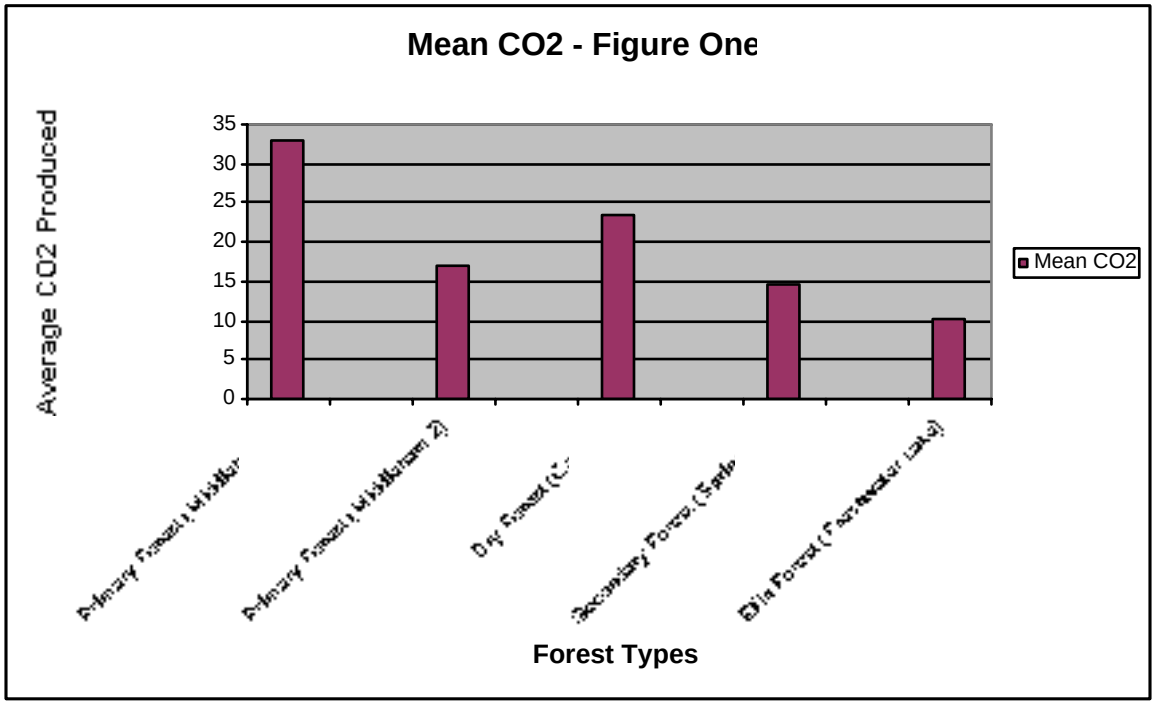
N=normality of the acid (1.0N)

E=equivalent weight; CO_2 =22

Results

Table One – Amount of Carbon Dioxide and pH Levels of Soils on Dominica

	Mean pH	Mean CO2
Primary Forest (Middleham Falls 1)	6	33
Primary Forest (Middleham Falls 2)	5.9	16.93
Dry Forest (Cabrits)	6.7	23.47
Secondary Forest (Springfield Plantation)	6.8	14.67
Elfin Forest (Freshwater Lake)	5.8	10.27



Discussion

Results from the Middleham Falls 1 sample were extremely variable and may be suscept.

After discussing my project with Dr. David Lang, a tropical soil scientist and expert on Dominican soils, I was able to determine that the results of the experiment cannot be interpreted completely due to a lack of information on each of the soils. According to Dr. Lang the information on pore space on each soil is needed to fully understand the experiment. This could be accomplished by getting a sample from each site, weighing that sample, drying the sample out (cook it in an oven), and determine the amount of pore space that each soil would have, in order to determine the amount of CO_2 a soil could hold. Soils with a large amount of pore space (such as rainforest soils) can potentially hold more water and presumably CO_2 than soils with less pore space (such as dry forest).

I can conclude, however, that the amount of CO_2 found in the elfin forest is accurate. According to Dr. Lang, acid soils in the elfin forest would have the least CO_2. My results indicate that soils in the dry forest have considerably more microbial activity than the others (Table 1, Figure 1). Dr. Lang noted that we would expect CO_2 production to be similar in dry forest and primary forest soils. Again the results may be influenced by differences in bulk density and pore space which I did not determine.

Future Reference

- Measure the amount of pore space for each soil type as a control for the experiment.
- Compare the results of the sample areas to each other by performing more than one sample from each site.

Works Cited

Zueber, PH.D. David. Texas A&M University. Exercise 11 Carbon Dioxide Evolution. Experiment taken from AGRO 405.

Evans, G.H. & James, Arlington. DOMINICA NATURE ISLAND: Nature Map. Faygate Printing, Sussex. 1997.

Lang, PH.D. David; Tropical Soil Scientist of Dominica; Personal Communication, June 16, 2002.

Appendix One

Soil Sample Survey

Primary Forest (Middleham Falls 1)

		CO_2 Results
Soil #1		
pH = 6.4		
Unamended	13.8	Nonconclusive due to air bubble
Amended	16.7	
Soil #2		
pH = 6.0		
Unamended	11.7	.2(22)= 4.4
Amended	11.5	
Soil #3		
pH = 5.6		
Unamended	15.4	2.8(22)= 61.6
Amended	12.6	

Dry Forest (Cabrits)

Soil #1		
pH = 6.8		
Unamended	10.5	.7(22)= 15.4
Amended	9.8	
Soil #2		
pH = 6.7		
Unamended	10	.6(22)= 13.2
Amended	9.4	
Soil #3		
pH = 6.7		
Unamended	12.5	1.9(22)= 41.8
Amended	10.6	

Secondary Forest (Springfield Plantation)

Soil #1		
pH = 6.8		
Unamended	12.4	1.6(22)=35.2
Amended	10.8	
Soil #2		
pH = 6.9		
Unamended	14.1	.2(22)= 4.4
Amended	13.9	

Soil #3
pH = 6.8

Unamended	11.1	.2(22)= 4.4
Amended	10.9	

Primary Forest (Middleham Falls 2)

Soil #1
pH = 6.2

Unamended	11.1	.2(22)= 4.4
Amended	10.9	

Soil #2
pH = 5.5

Unamended	14.5	1(22)= 22
Amended	13.5	

Soil #3
pH = 6.1

Unamended	13.7	1.1(22)= 24.2
Amended	12.6	

Elfin Forest (Freshwater Lake)

Soil #1
pH = 6.3

Unamended	13.6	.6(22) = 13.2
Amended	13	

Soil #2
pH = 5.2

Unamended	11.9	.2(22)= 4.4
Amended	11.7	

Soil #3
pH = 5.9

Unamended	13.2	.6(22) = 13.2
Amended	12.6	