Carbons Stock Assessment as Basis for Public Green Spaces Planning and Management in Bacolod City and Iloilo City

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Abstract

The study aimed to determine the carbon stock in the biomass of trees and soil organic carbon (SOC) in public green spaces of Bacolod City and Iloilo City from March 2009 to May 2011 using Brown's allometric equation. Data showed that Bacolod City Plaza had the highest carbon storage with 189.02 t/ha. This was followed by Capitol Park and Lagoon, 93.84 t/ha and Pana-ad Park and Stadium 56.12 t/ha. In Iloilo City, Plaza Libertad had the highest stored carbon in biomass with 250.88 t/ha, followed by Jaro Plaza with 116.95 t/ha and Lapaz Plaza with 75.77 t/ha. The average carbon stock per hectare showed that Iloilo had 147.90 t/ha which was higher than that of Bacolod City with 112.99 t/ha. Data on soil organic carbon (SOC) showed that Bacolod City Plaza had 42.93 t/ha SOC at 0 to 15 cm depth while Pana-ad Park and Stadium had 42.02 t/ha and Capitol Park and Lagoon with 34.71 t/ha. In Iloilo City, SOC at 15 cm depth, Jaro Plaza had 43.85 t/ha, Plaza Libertad had 43.24 t/ha and Lapaz Plaza had 37.76 t/ha. The Green spaces in Iloilo City at 0 to 15 cm depth had higher mean SOC content with 41.62 t/ha at 0 to15 cm depth compared to Bacolod City (39.89 t/ha). At 16-30 cm depth, the green spaces of Iloilo City had higher SOC (36.95 t/ha) compared to in green spaces of Bacolod City (30.85 t/ha).

Keywords: biomass, bulk density, carbon stock, green space, soil organic carbon

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Climate change is one of the inevitable environmental problems that our planet is facing. This was brought mainly by increasing level of greenhouse gases, and CO_2 was considered as the highest causal factors in global warming (Warran & Patwadhan, 2009). Carbon dioxide is a dominant greenhouse gas. Increased atmospheric CO_2 is attributable mostly to fossil fuel combustion (about 80-85%) and deforestation worldwide (Schneider, 1989; Hamburg et al., 1997, Nowak & Crane, 2002). Atmospheric carbon is estimated to be increasing by approximately 2600 million metric tons annually (Sedjo, 1989; Nowak & Crane, 2002).

Trees act as a sink for CO_2 by fixing carbon during photosynthesis and storing excess carbon as biomass. The net long-term CO_2 source or sink dynamics of forests change through time as trees grow, die, and decay. In addition, human influences on forests can further affect CO_2 source/sink dynamics of forests through such factors as fossil fuel emissions and harvesting/utilization of biomass. Increasing the number of trees might potentially slow the accumulation of atmospheric carbon (Nowak & Crane, 2002).

Urban forest plays a very critical role in carbon dioxide sequestration and storage since most of the emissions occurred in the urban areas. They also provide shades in buildings, reduce energy consumption, and mitigate the urban heat island effect (Gann, 2003).

Green spaces include trees and other vegetation that are planted in public places such as plaza and recreation centers, road system, and perimeter of government offices, hospitals and public schools (Palijon, 2002; Tutor, 2010). Trees in green spaces were planted and maintained for their aesthetic and environmental values since they provide a long-term carbon storage. This study was conducted to determine the carbon stocks of trees in public green spaces in Bacolod City and Iloilo City, Philippines.

In addition to carbon sequestration, trees play a very important role in maintaining a healthy and wholesome environment in urban areas (Talarchek, 1987). Urban trees improve air quality, minimize noise pollution, improve microclimate, control flow of water and run-off, serve as wildlife habitat, provide psychological benefits to people, enhance the quality of life, and increase land values. Vegetation in urban areas acting in conjunction with other natural and cultural components of the ecosystem maintains a wholesome environment for urban populace.

Methodology

Location of the Study

This study was conducted in public green spaces in two major urban cities of Western Visayas. These public green spaces are planted with various trees, and other vegetation, some of which were established before World War II. These green spaces are the Bacolod City Plaza, Capitol Park and Lagoon and Pana-ad Park and Stadium in Bacolod City. In Iloilo City, they are at Plaza Libertad, Lapaz Plaza, and Jaro Plaza.

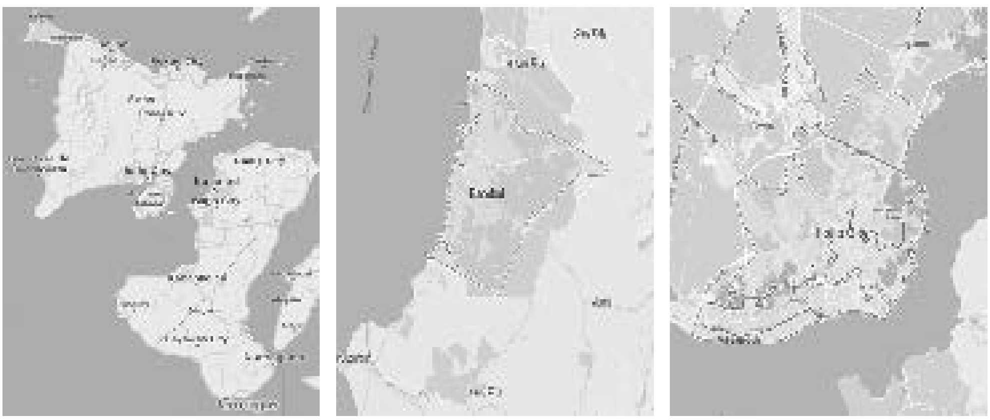

Figure 1. Location map of Bacolod City and Iloilo City (Source: Google map).

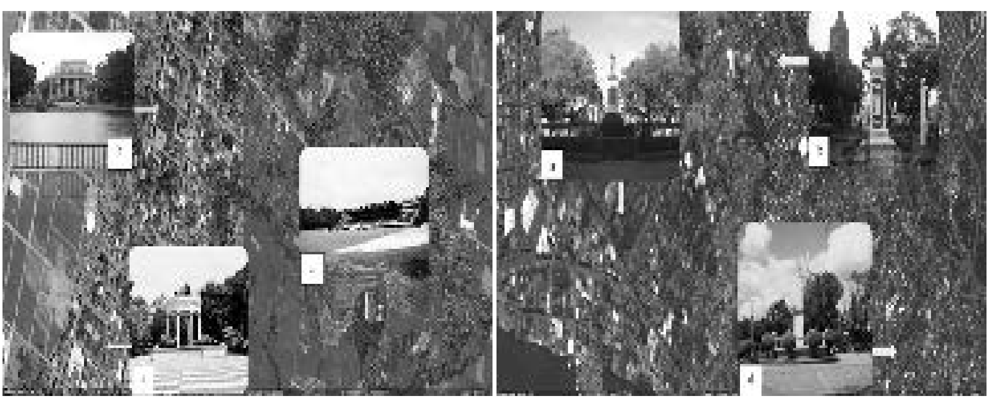

Figure 2. Location map of study site, left Bacolod City: (a) Bacolod City Plaza, (b) Capitol Park and Lagoon and (c) Pana-ad Park and Stadium right Iloilo City: (a) Plaza Libertad (b) Jaro Plaza (c) Lapaz Plaza (Source: Google Earth).

Data Gathering

Determination of carbon content in biomass and soil. Complete enumeration of trees in the green space was conducted. Only trees with diameter at breast height of ≥ 5.0 cm and higher were included in tree biomass determination.

Total above ground biomass (including branches and leaves) of individual trees was determined using the allometric equation developed by Brown (1997 cited in Banaticla, Sales & Lasco, 2007).

$$Y = exp[-2.134 + 2.53 * ln(D)]$$

Where: $Y = total\ aboveground\ biomass\ (kg)$,and
$D = dbh\ (cm)$

Biomass was converted into carbon by a factor of 0.45 (Woomer & Palm, 1998 cited cited by Racelis, 2000; Lasco, 2002 as cited in Tiburan, Carandang, Bantayan, & Cruz, 2005).

Determination of soil organic carbon. Three soil cores were obtained from the different greens spaces studied. Volume was determined and weighed for its initial weight. The soil samples were ovendried for 48 hours at the Soil Laboratory of Ecosystem Research and Development Bureau, College, Laguna and the final weight were computed:

$$Bulk\ Density = \frac{Ovendry\ weight}{Volume}$$

Ten (10) soil samples were randomly collected from each of the green space, and thoroughly mixed to get a one (1) kilogram composite sample. The samples were air dried and properly labeled for soil analysis. Soil samples were taken from 0 to 15 cm and 16 to 30 cm depth. Soil organic matter (SOM) was analyzed at the Regional Soil Laboratory of the Department of Agriculture- Region VI.

Soil organic carbon was determined using the equation:

$$SOC = BD\ x\ OM\ (.58)\ x\ area\ in\ ha\ x\ depth\ of\ soil$$

Where:

SOC – soil organic carbon
OM = Organic matter (%)
Area = 10,000 m^2/ha
Depth of soil = 0- 15 cm and 16 – 30 cm

Data Analysis

Descriptive statistics was used to analyze data of this study, T-Test was used to determine to compare means between data in Bacolod city and Iloilo City.

Results and Discussion

Carbon Content in the Biomass

The amount of carbon from biomass of trees using Brown's allometric equation is presented in Table 1. Bacolod City Plaza had the highest carbon storage with 189.02 t/ha. This was followed by Capitol Park and Lagoon, 93.84 t/ha and Pana-ad Park and Stadium 56.12 t/ha

Among the green spaces of Iloilo City, Plaza Libertad had the highest stored carbon in biomass with 250.88 t/ha. This was followed by Jaro Plaza, 116.95 t/ha and Lapaz Plaza, 75.77 t/ha.

Bacolod City tree biomass had higher total carbon content with a total of 879.18 tons compared to Iloilo City, 653.16 tons. It was observed that trees in Bacolod City Plaza have higher mean dbh compared to other green spaces. It was also established ahead of other green spaces in Bacolod City where trees are evident to have higher diameter.

In terms of average carbon content per hectare, it showed that Iloilo had 147.90 t/ha which was higher than that of Bacolod City, of 112.99 t/ha. Trees in urban green spaces of Iloilo City were denser than in Bacolod City especially in Plaza Libertad where trees are older and have highest average diameter than other green spaces studied.

T-test showed no significant difference between amounts of carbon stock in the green spaces of two cities.

Old trees stored carbon via their biomass, while younger trees can effectively sequester CO_2 through photosynthesis. The amount of carbon sequestered annually from large and healthy trees (Cumming, Galvin, Rabaglia, Cumming, & Twardus, 2001). Thus, maintaining healthy trees in the green spaces increases carbon sequestration from the atmosphere.

Carbon storage of the trees in the green spaces of two urban cities of Western Visayas was lower than that of a 25-year old mahogany plantation in Leyte with 159.00 t/ha but higher than the total C storage capacity of a 15-year-old *Gmelina arborea* which was 64.00 t/ha (Sales, Lasco & Banaticla, 2005). In Sacramento County, McPherson (1998) found that 6 million trees could store as much as stored 8 million tons of CO_2 (31.00 t/ha), and sequester 238,000 tons (0.92 t/ha) of CO_2 annually.

Table 1

Carbon stored on the biomass of trees in the green spaces.

Greenspace	Area (Ha)	Total Carbon (Tons)	Carbon/Hectare (Tons/Ha)
Bacolod City			
Bacolod City Plaza	1.04	196.58	189.02
Capitol Park and Lagoon	2.31	216.76	93.84
Pana-ad Park and Stadium	8.30	465.84	56.12
Total		879.18	338.98
Mean		293.06	112.99
Iloilo City			
Jaro Plaza	1.77	207.00	116.95
Lapaz Plaza	2.61	197.77	75.77
Plaza Libertad	0.99	248.37	250.88
Total		653.15	443.61
Mean		217.72	147.89
t-Test			ns

Note: ns= not significant

Soil Organic Carbon

Data on soil organic carbon (SOC) is presented in Table 1. Bacolod City Plaza had 42.93 t/ha soil organic carbon at 0 to 15 cm depth. This was followed by Pana-ad Park and Stadium had 42.02 t/ha and Capitol Park and Lagoon had 34.71 t/ha. Total Carbon content in Pana- ad Park and Stadium was 348.77 tons, Capitol Park and Lagoon was 80.19 tons in and Bacolod City Plaza was 44.65 tons.

At 0 to 15 cm depth, Jaro Plaza had 43.85 t/ha, Plaza Libertad had 43.24 t/ha and Lapaz Plaza had 37.76 t/ha (Table 2). Total carbon content at 0 to 15 cm depth showed that Lapaz Plaza had the highest SOC content with 98.55 tons. While Jaro Plaza had 77.61 tons and Plaza Libertad had 42.81 tons.

The Green spaces in Iloilo City at 0 to 15 cm depth had higher mean SOC content with 41.62 t/ha at 0 to15 cm depth compared to Bacolod City (39.89 t/ha). T-Test showed no significant difference between mean SOC of green spaces of Bacolod City and Iloilo City.

Table 2

Soil organic carbon at 0 – 15 cm depth in the green spaces

Greenspace	SOC/Hectare (t/ha)	Total SOC (Tons)
Bacolod City		
Bacolod City Plaza	42.93	44.65
Capitol Park and Lagoon	34.71	80.18
Pana-ad Park and Stadium	42.02	348.78
Total	119.67	473.61
Mean	39.89	157.87
Iloilo City		
Jaro Plaza	43.85	77.61
Lapaz Plaza	37.75	98.55
Plaza Libertad	43.24	42.81
Total	124.84	218.97
Mean	41.62	72.99
t-Test		ns

Note: ns=not significant

At 16 to 30 cm depth, Bacolod City Plaza had the highest SOC with 41.11 t/ha followed by Pana-ad Park and Stadium, 28.49 t/ha and Capitol Park and Lagoon, 22.97 t/ha. Across the green spaces in Pana-ad Park and Stadium contributed the highest total carbon with 236.49 tons, Capitol Park and Lagoon with 53.06 tons and Bacolod City Plaza with 42.75 tons (Table 3).

At 16-30 cm depth, Lapaz Plaza had the highest with 92.99 tons, Jaro Plaza, 68.45 tons and Plaza Libertad, 36.17 tons.

At 16-30 cm depth, the green spaces of Iloilo City had higher SOC (36.95 t/ha) compared to the green spaces of Bacolod City (30.85 t/ha). The t –test analysis showed that SOC between two cities were statistically the same.

The soil carbon pool was a major component of the global carbon cycle (Lal & Follett, 2009). They added that, it significantly impacts on: (a) the atmospheric composition of radiatively active gases (e.g., CO_2, CH_4, N_2O), (b) elemental cycling, (c) purification of water by denaturing and filtering pollutants, (d) soil quality and net primary productivity, and (e) activity and species diversity of soil flora and fauna.

Most of the forest litter were removed from the green spaces and dumped in the designated garbage dump site. This practice alters the natural process of flow of carbon from the atmosphere to the soil. However, burning was also common practice in the green spaces especially in Pana-ad Park and Stadium. Burning is not a sound practice for carbon sequestration because it enhances carbon emission to the atmosphere.

The average soil carbon in Bacolod and Iloilo City was lower than the average soil carbon of Urban Green Space (UGS) in three major urban cities in South Korea at 30-cm depths with 105.6 GtC for Seoul, 43.6 for Daegu, and 26.4 for Daejeon or an average of 58.53 GtC/ha (Yoon, Seo, Park, Son, & Son, 2016).

Table 3

Soil organic carbon (SOC) at 16-30 cm depth in the green spaces.

GREENSPACE	SOC/ HECTARE (t/ha)	TOTAL SOC (tons)
Bacolod City		
Bacolod City Plaza	41.11	42.57
Capitol Park and Lagoon	22.97	53.06
Pana-ad Park and Stadium	28.49	236.48
Total	92.57	332.30
Mean	30.86	110.77
Iloilo City		
Jaro Plaza	38.67	68.44
Lapaz Plaza	35.63	92.98
Plaza Libertad	36.54	36.17
Total	110.84	197.61
Mean	36.95	65.87
t-Test		ns

Note: ns- not significant

Conclusion and Recommendations

Trees on the green spaces of Bacolod City and Iloilo City stored large amount of Carbon in their biomass. Since trees were in green spaces were planted for their aesthetic and environmental services, it plays a very important role in carbon storage and sequestration.

Soil in green spaces also stored considerable amount of organic carbon (SOC), although lower than SOC in plantation and natural forest. This was attributed by daily removal of forest litter from the green spaces. Replanting of dead trees was practiced by LGU while Capitol Park and Lagoon dead, branches and leaf litters are used in composting and returned as organic fertilizer in the park.

It is recommended that proper cultural practices shall be employed to enhance growth and health of trees to increase and prolong their carbon storage and sequestration. Dead and hazardous trees shall be replaced to maintain adequate green cover of the green spaces.

It is also highly recommended that composting should be practiced and forest litter removed from the green spaces should be returned as compost to fertilize trees and other ornamental plants therefore, increase SOC storage capacity of green spaces.

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