Atmósfera 29(3), 189-196 (2016)
doi: 10.20937/ATM.2016.29.03.01

Estimated carbon dioxide exchange for three native species in an ecological reserve of Mexico City

ERIKA SÁNCHEZ-LEÓN, TELMA CASTRO, ÓSCAR PERALTA, HARRY ÁLVAREZ-OSPINA, MARÍA DE LA LUZ ESPINOSA and AMPARO MARTÍNEZ-ARROYO
Centro de Ciencias de la Atmósfera, Universidad Nacional Autónoma de México, Circuito de la Investigación Científica s/n, Ciudad Universitaria, 04510 Ciudad de México, México
Corresponding author: Erika Sánchez-León; email: erikas@atmosfera.unam.mx

Received: December 10, 2015; accepted: May 11, 2016

RESUMEN

Se estimó la captura y emisión de CO_2 de tres especies (*Buddleia cordata*, *Senecio praecox* y *Echeveria gibbiflora*) en la Reserva Ecológica del Pedregal de San Ángel. El muestreo se realizó durante los meses de febrero, marzo, abril y noviembre (temporada seca) y de julio a octubre (temporada de lluvias) en 2010. En la temporada seca *B. cordata* y *S. praecox* capturaron 16.14 y 3.25 kg de CO_2, respectivamente, en tanto que *E. gibbiflora* emitió 45.76 kg de CO_2. En la temporada de lluvias el intercambio de CO_2 fue diferente para las tres especies. La tasa de fotosíntesis durante la temporada seca y de lluvias fue respectivamente de 22 y 6 µmol CO_2 m^{-2} s^{-1} para *B. cordata*, 27 y 5.25 µmol CO_2 m^{-2} s^{-1} para *S. praecox*, y 29 y 3 µmol CO_2 m^{-2} s^{-1} para *E. gibbiflora*. Adicionalmente, se estimó el índice de vegetación de diferencia normalizada con datos de MODIS. Los resultados indican que la intensidad del verdor en el sitio aumentó durante los meses de lluvia. En este trabajo se explica la contribución de dichas plantas al ciclo de carbono en un ecosistema ubicado dentro de una zona urbana, así como la relación de variables ambientales como temperatura, densidad del flujo fotosintético de fotones y humedad relativa en la captura o emisión de CO_2. Este trabajo proporciona información sobre la dinámica del ciclo del carbono en ecosistemas urbanos, lo cual puede ser útil para estudios futuros sobre la mitigación del cambio climático.

ABSTRACT

Capture and emission of carbon dioxide of three species (*Buddleia cordata*, *Senecio praecox* and *Echeveria gibbiflora*) in the Reserva Ecológica del Pedregal de San Ángel (Ecological Reserve of the Pedregal de San Ángel), were estimated. CO_2 sampling was carried out in 2010 during the dry (February, March, April and November) and rainy seasons (July to October). On the dry season *B. cordata* and *S. praecox* captured 16.14 and 3.25 kg CO_2, respectively, whereas *E. gibbiflora* emitted 45.76 kg CO_2. In the rainy season the exchange of CO_2 was different for the three species. In the dry season, the photosynthetic rate was 22 µmol CO_2 m^{-2} s^{-1} for *B. cordata,* 27 µmolCO_2 m^{-2} s^{-1} for *S. praecox* and 29 µmolCO_2 m^{-2} s^{-1} for *E. gibbiflora.* In the rainy season they were 6, 5.25 and 3 µmol CO_2 m^{-2} s^{-1}, respectively. In addition, MODIS data were used to estimate the normalized difference vegetation index (NDVI), indicating that the intensity of greenery at the site increased during the rainy months. This paper explains the contribution of studied plants to the carbon cycle of an ecosystem located within an urban area, and the relationship of environmental variables such as temperature, density photosynthetic photon flux and relative humidity in the capture or emission of CO_2. This work provides valuable information about the carbon cycle dynamics on urban ecosystems, which can be useful in future studies for climate change mitigation.

Keywords: Photosynthesis, *Buddleia cordata*, *Senecio praecox*, *Echeveria gibbiflora*, capture and emission CO_2, Mexico City.

1. Introduction

The global warming phenomenon, which is caused by emissions of greenhouse gases (GHGs) that contribute to an increase in earth surface temperature, is presented nowadays as a problem for the development of life on earth. Carbon dioxide (CO_2) is one of the gases that most favors the heating process, and its concentration has increased in recent years mainly due to anthropogenic activities, going from 280 ppm in pre-industrial times to 398.72 ppm in 2014 (IPCC, 2007; NOAA, 2014). According to the national inventory of GHGs of Mexico, the total CO_2 emissions were 493.45 Mt in 2010, contributing with 65.9% to the total inventory and having an increase of 23.6 % compared to 1990 (INE, 2010).

There are various carbon sinks in the world that have been associated to an important contribution of forests, which are responsible for 60% of the net sequestration of carbon dioxide (Nobel, 2009). It is estimated that the world's forests capture over 650 Mt of carbon, which helps to mitigate climate change and preserve biodiversity (FAO, 2010). However, not only forests sequestrate CO_2; it has been shown in several studies that the presence of trees in urban areas favors the reduction of some air pollutants and contributes to carbon sequestration (Yang *et al.*, 2005; Kordowski and Kuttler, 2010; Velasco *et al.*, 2013). There are several techniques for estimating carbon sequestration; one of them is through the use of technologies such as satellite imagery from the Moderate Resolution Imaging Spectroradiometer (MODIS), whose purpose is to model carbon and water cycles globally. Furthermore, MODIS allows measuring ecosystem's primary productivity, vegetation indices and other environmental variables (Zhao *et al.*, 2005).

The captured carbon is also estimated using different models, which evaluate photosynthetic and environmental parameters (Kim and Lieth, 2003; Schultz 2003; Xu and Baldocchi, 2003; Sharkey *et al.*, 2007), whereas others evaluate the carbon balance between plants and the atmosphere (Harnos *et al.*, 2006). Several experimental studies of photosynthesis use CO_2 analyzers and measurements in situ (Myers *et al.*, 1999; Long and Bernacchi, 2003; Kitao *et al.*, 2007). However, few studies have evaluated the importance of individual species concerning their contribution to CO_2 capture and emission in the environment. This information provides knowledge over the role of vegetation. Urban forests can contribute significantly to the reduction of air pollution by relieving the intensity of the heat island (Yang *et al.*, 2005). Velasco *et al.* (2013) mentioned that vegetation in an urban area contributes to the capture of CO_2 during the day and promotes local air cooling due to transpiration, serving as an alternative mitigation for climate change.

In this study our objective was to estimate CO_2 capture and emission through the photosynthetic rate of three endemic plants (*E. gibbiflora*, *B. cordata*, and *S. praecox*) and the relationship between temperature (T), density photosynthetic photon flux (DPPF), and relative humidity (RH) in dry and rainy seasons at the Reserva Ecológica del Pedregal de San Ángel (Ecological Reserve of the Pedregal de San Ángel, REPSA); we also estimated the contribution to the carbon cycle to understand the role of urban plant ecosystems in climate change mitigation. This site was chosen because it is one of the few protected natural reserves located in a megacity; moreover, it is of great value for the conservation of biodiversity and it provides environmental services to the south of the metropolitan area of Mexico City. It also has a special ecosystem, a xerophilus shrubland settled into a basaltic substrate whose soils are scarce and shallow (Rzedowski, 1954), which is the reason why this work is focused on the aboveground biomass. The carbon cycle in vegetation starts with CO_2 fixation mainly in the photosynthetic processes in which the plants absorb CO_2 from the atmosphere to produce oxygen and carbohydrates through solar radiation. We hypothesized that different climatic conditions produce significant changes regarding the carbon balance during the dry and rainy seasons.

2. Experimental

2.1 Sampling site description

This study was conducted in the REPSA, located southeast of Mexico City (19º 17' N, 99º 11' W). It covers an area of approximately 273 hectares and its nominal elevation is 2329 masl. The vegetation consists of xerophilous shrubs and dominant life forms are herbs and shrubs (Castillo-Argüero *et al.*, 2007; Chávez and Ceballos, 2009). According to Jáuregui (2000) the climate has dry and rainy seasons. The dry season runs from November to May and the rainy