

Original Research

Effects of Forests on Amounts of CO₂: Case Study of Kastamonu and Ilgaz Mountain National Parks

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Abstract

The CO₂ cycle on earth in the last 400,000 years shows that CO₂ in the atmosphere increased every 80,000 years and 100,000 years on average and then dropped back later. Although there is 0-0.03% (0-300 ppm) carbon dioxide (CO₂) in the air, it has a vital importance because of its amount and variety. Plants reduce the amount of CO₂ in the atmosphere with photosynthesis. But plants cannot do photosynthesis in winter or night. As a result, they might have a negative impact on the amount of CO₂. In this study, the amounts of air carbon dioxide are measured in forests and urban areas and evaluated depending on season and day or night. Results of our study show that, despite the amount of carbon dioxide decreases in the summer depending on the sunlight, it can double its level at night. In addition to day and night, there is a big difference between the amount of carbon dioxide in terms of summer and winter seasons.

Keywords: air pollution, air quality, carbon dioxide (CO₂) amount, environmental problem, impacts on forest, seasonal change, urban cities

Introduction

Although carbon dioxide (CO₂) is found in the air at a level of 0-0.03% (0-300 ppm), it is a vital gas in terms of amount and variability. Of the carbon dioxide that is mixed into the atmosphere, approximately 80-85% is generated by the use fossil fuels. The respiration processes of living things and the decomposition of organic substances regenerate the remaining 15-20% by microorganisms [1]. The amount of carbon dioxide increases due to human activities, especially in densely populated regions, and reaches health-threatening levels in certain cities.

The CO₂ cycle on earth in the last 400,000 years shows that CO₂ in the atmosphere increased every 80,000 years

and 100,000 years on average and then dropped back later. The highest CO₂ amount throughout the past 400,000 years was 320 ppm. However, CO₂ in the atmosphere is currently around 385 ppm. This increase is not caused by the natural cycle of nature; it is a human-induced increase [2].

After health problems related to air quality gained prominence, air quality has been an important factor in people's preferences about the city they will live. In cities with clean air, large forest areas that do not have sources of contamination began to be considered and preferred as more habitable [3].

The carbon storage values are slightly lower than the US cities average because of differences in forest structure. Urban trees can affect carbon emissions in urban areas. Planting trees around buildings can reduce building energy use, besides reducing emissions for plants. [4-6]. All trees,

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which are in the growth process, diminish carbon dioxide from the air. A growing tree stores carbon in its tissue each year [7].

The cities that have large forest areas are considered areas with high air quality. Although plant elements consisting of the forest cannot do photosynthesis, they respire when one of the conditions necessary for photosynthesis are lacking. As a result, they might have a negative impact on air quality. On the other hand, the literature does not contain enough research on levels of forests on air quality.

This study was carried out to determine seasonal changes of carbon dioxide amounts in the forests of Kastamonu province and the effects of this change on air quality of Kastamonu city center. Forest Lands cover approximately 65% of the area of Kastamonu Province.

Material and Method

The study was simultaneously carried out in Kastamonu city center and Ilgaz Mountain National Park, which has the highest forest density in the region. Kastamonu is one of the oldest settlements in Turkey, and the settlement in the city is generally developed in a valley.

Kuzeykent region is located north of the city and began to develop at the end of the 1990s. This region shows significant differences from the city center in terms of structure. Since Kuzeykent is an open region with high air currents, in this study it was considered a separate region outside the city center. An “extech EA80 indoor air quality meter was used to measure day and night CO₂ levels in summer and winter in Kastamonu city center, Kuzeykent region and the forests in Ilgaz Mountain National Park. Fig. 1 shows where the measurement was taken. The mea-

surements were performed with a minimum 10 repetitions. The measurements were carried out in 2012 May-2013 April.

Results and Discussions

The results of the measurements performed in Kastamonu city center, Kuzeykent, and forest lands are summarized in Table 1.

Measurements in the study are vegetation seasons starting between April and June (Kastamonu city center and Kuzeykent is in April, Ilgaz Mountain National Park is in June). The vegetation season finishes between September and November (Ilgaz Mountain National Park is in September, Kuzeykent is in November). The studies in July to August and in January to February were carried out in the middle of the day or night (in daytime hours at 12.00 to 14.00, night hours at 01.00 to 03.00).

The weather was without rain and wind in this study area when the measurement was taken. A study conducted in windy weather quickly can change the amount of CO₂ determined [8]. Therefore, in order to obtain reliable results the measurements were carried out with no wind.

When it taken into consideration that the measurements in the study were carried out outside the vegetation season, it can be stated that seasonal conditions have a significant effect on air quality. A forest could improve the environment and air quality.

The results showed that the lowest CO₂ value (121 ppm) was measured in daytime in the forest, while the highest mean values were measured in nighttime in the city center in winter. It was found that CO₂ amounts in the city center increased to 918 ppm in nighttime in winter months.

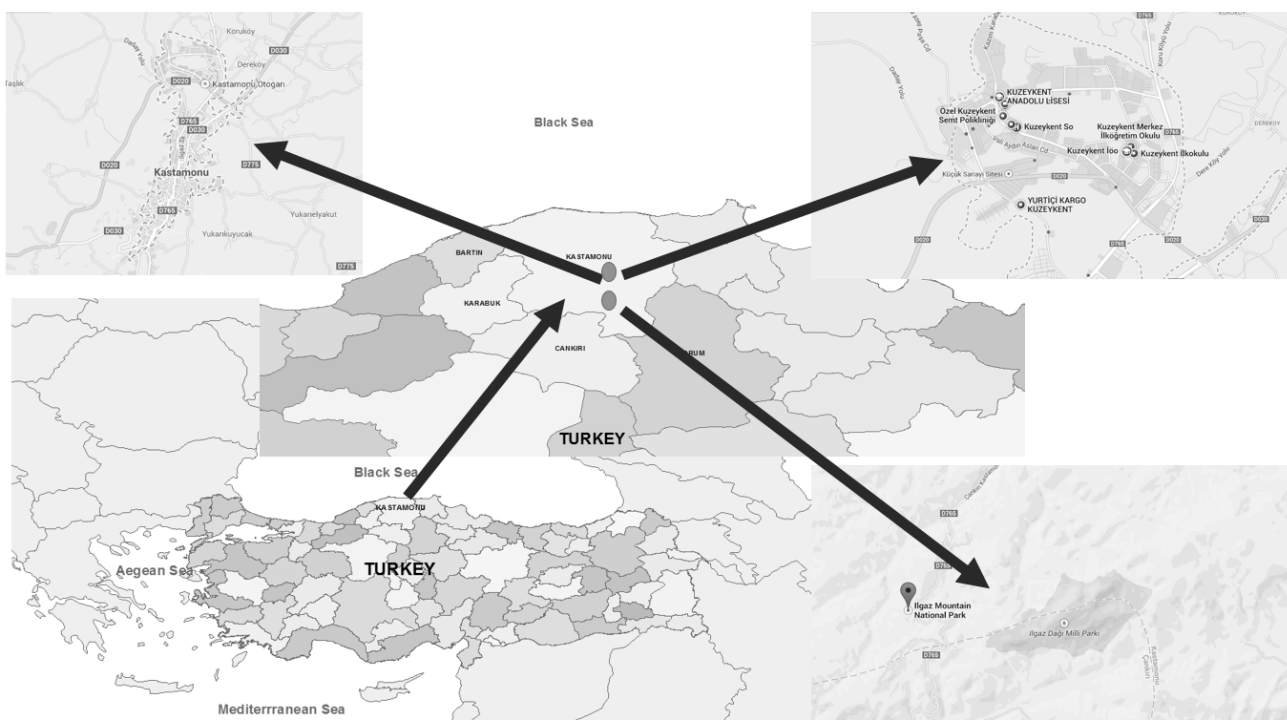


Fig. 1. Showing to measure CO₂ in Kastamonu city center, Kuzeykent region, and the forests in Ilgaz Mountain National Park.

Table 1. Measurement results.

Measurement time		Forest	City Center	Kuzeykent	
Summer	Day	Max	203	512	265
		Min	121	325	198
		Mean	148	398	230
	Night	Max	271	439	358
		Min	199	358	236
		Mean	229	401	297
Winter	Day	Max	450	720	456
		Min	330	517	415
		Mean	391	621	438
	Night	Max	502	918	514
		Min	357	552	427
		Mean	422	758	473

All of the measurements showed higher mean values in winter months than summer months and highest mean values in nighttime than daytime. Comparison of simultaneous measurements showed that the highest value was measured in the city center, while the lowest value was measured in the forest.

It was found that CO₂ amounts, which were 398 ppm in daytime in summer, did not show a significant difference at night. However, in wintertime it increased from 621 ppm in daytime to 758 ppm in the nighttime. On the other hand, mean daytime CO₂ level was 230 ppm in summer months; however, it increased to 297 ppm in nighttime. It was observed that CO₂ levels in winter months were 438 ppm in daytime but increased to 473 ppm in nighttime.

CO₂ amounts in forest area decreased to 121 ppm in summer months in daytime. Mean CO₂ amount was calculated as 148 ppm. However, it was found that CO₂ amount showed a more than 50% increase in the nighttime and reached 229 ppm. On the other hand, it reached 391 ppm in daytime and 422 ppm in nighttime in winter months.

Air pollution is one of the most important environmental problems brought by modern life [9]. Every year more than 3 million people lose their lives due to air pollution [10]. After health problems related to air quality gained prominence, air quality has been an important factor in people's preferences about the city they will live. In cities with clean air, large forest lands that do not have sources of contamination began to be considered and preferred as being more habitable [3].

Air pollution can be defined as the presence of one or more contaminants in the atmosphere in an amount and time to damage human, plant, and animal life; commercial or personal goods; and environment quality [11]. Among these contaminants, CO₂ has gained prominence, especially with global warming, and became the most widely studied gas in recent years.

CO₂ amounts in city centers have been analyzed by various studies. Studies in the literature reported CO₂ amounts in city centers as follows: 411 ppm in Kraków, Poland [12]; 477 ppm in Rome [13]; 384 ppm in the Spanish Plateau [14]; 478 ppm in Korea [15]; 373 ppm in Hawaii [16]; 475 ppm in Dallas [17]; 555 ppm in Phoenix, Arizona [18]; 384 ppm in Chicago [19]; 397 ppm in California [20]; 590 ppm in Tel-Aviv [21]; 425 ppm in Vilathur, India [22]; and 384 ppm in Brazil [23]. In addition, one of our studies is assessing forests and lands with carbon storage amount by trees in the state of Delaware, USA, calculated and mapping it by geographic information systems (GIS). The map helps us understand Delaware's urban forest. It has the carbon storage map [7]. However, there is a limited body of research on the effects of forests on quality.

Plants are living organisms and need certain conditions to survive in their living environment. They change the conditions in their living environment with their metabolic activities. However, this process is reversed in plants that release oxygen and absorb carbon dioxide from the environment when the conditions are suitable for plant development [24].

When the conditions in their living environment are suitable, they do photosynthesis; however, if the conditions in their living environment are not suitable they do respiration. Plants cannot do photosynthesis when CO₂ amounts fall to around 150 ppm and they begin to fade. When this level further falls to around 100 ppm, photosynthesis completely stops and plants die. The 100 ppm level is the lower limit for plant life [25].

The results of the present study show that CO₂ amount decreased to 121 ppm in the forest area in daytime. However, the lowest values measured in the city center were 325 ppm. In the Kuzeykent region with high air circulation, it was found that CO₂ amount dropped to 198 ppm. This indicates the importance of air circulation in transport of clean air and thus in air quality.

Of the carbon dioxide that is mixed into the atmosphere, approximately 80-85% is generated by the use of fossil fuels. The respiration processes of living things and the decomposition of organic substances generate the remaining 5-20% by microorganisms [1]. High CO₂ amounts in city centers are generally related to human activities. Especially the use of solid fuel for heating purposes in winter significantly increases CO₂ amounts.

Previous research has determined that air quality parameters were affected by various factors such as air current, traffic density, and seasonal changes [8]. The results of the present study showed the important role of forests on air quality. Mean CO₂ amount was 148 ppm in forest in daytime and 229 ppm in nighttime in summer months. However, it increased to 398 ppm in daytime and 401 ppm in nighttime in the city center. In wintertime, CO₂ was 391 ppm in the forest and 621 ppm in the city center in daytime. On the other hand, it was 422 ppm in the forest and 758 ppm in the city center in nighttime. The clean air in the forest area is transported to the city center by the air current and increases the air quality in the city center.

Conclusion

The results show that the air quality parameter plays an important role. Improvement of air quality as a result in Kastamonu forest should be extended. It was determined that CO₂ amounts increased at locations with high human activities. Forests are a greater impact of all tree areas than non forest areas because of reducing environmental energy, carbon emissions, and growing faster trees. Forests can absorb the carbon. We need to calculate more fields to help improve air quality. Additionally, research needs to develop better trees, researching the effect of urban trees on carbon storage in cities. Air quality needs to understand developing management plans and national policies for extending forests in order to improve air quality.

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