Measuring the Impact of Selected Plants on Indoor CO_2 Concentrations

Mehmet Cetin[1]*, Hakan Sevik[2]

[1]Kastamonu University, Faculty of Engineering and Architecture, Department of Landscape Architecture,
37150, Kastamonu, Turkey
[2]Kastamonu University, Faculty of Engineering and Architecture, Department of Environmental Engineering,
37150, Kastamonu, Turkey

Abstract

Nearly 90% of people's lives are lived indoors, and their health is affected by the concentrations of CO_2 in these spaces. Carbon dioxide concentrations can rapidly change based on human activity in indoor living spaces. Indoor plants and the concentration of CO_2 in the local environment are factors that influence most people. Plants, depending on the ambient light and temperature conditions, and which are necessary to perform photosynthesis or respiration, directly affect the concentration of CO_2 in the local environment. Furthermore, indoor plants influence the level of CO_2 in the local environment but have not been researched enough in recent years concerning their specific effects. This study attempts to determine the effects of indoor plants on the concentration of CO_2 in an indoor environment under certain light conditions. Five indoor plants were placed in a glass-walled compartment in order to measure the amount of CO_2. The glass compartment used in the study was positioned in a way to prevent direct sunlight yet provide an illuminated environment. The plants were placed into this airtight compartment with a glass wall, which had a volume of approximately 0.5 m³ (0.7 m x 0.7 m x 1 m). The measurements of CO_2 within the compartment were carried out via Extech Desktop Indoor Air Quality CO_2 Datalogger, and the CO_2 measuring device placed in the compartment was set to measure CO_2 once every five minutes. The study found that all plants reduced the concentration of CO_2 to a certain extent during the day.

Keywords: air quality, people's health, carbon dioxide, CO_2, indoor, indoor plants

Introduction

In 2000, 47% of the world's population (2.9 billion people) lived in urban areas. Scientists have predicted that anywhere from 60% to 90% of the world's population will live in cities by the 2030s. In European countries, more than two thirds of the total population live in urban areas [1-3]. Also, people living in cities spend at least 80% of their lives in indoor spaces [4].

The quality of air in indoor spaces, then, is of great relevance to human health. Any decrease in indoor air quality directly affects human health and performance [5].

CO_2 is one of the gases whose concentration can change rapidly as a result of indoor human metabolic activities. Air composed of 21% O_2 and 0.033% CO_2 taken in by people from the normal atmosphere becomes 16-17% O_2 and 4% CO_2 content during discharge from the

---

*e-mail: mehmet.cetin@temple.edu

lungs. This change leads to a rapid rise in CO_2 content in environments like schools, shopping malls, and hospitals, where people tend to congregate [6]. Increases in the CO_2 content in an environment can cause fatigue, absence of perception, and sleepiness. Furthermore, higher CO_2 concentrations tend to bring about several complaints that result in loss of performance but whose cause cannot be easily determined. When the concentration of CO_2 in an environment is more than 1,000 ppm, people experience headache, dizziness, fatigue, and loss of concentration, and they will notice and become annoyed by the odor of the gas; when the concentration of CO_2 is more than 1,500 ppm, people experience throat irritation, nose irritation, nasal discharge, cough, and eye discharge [7].

One of the most effective ways to improve indoor air quality is maintaining proper ventilation. U.S. Environmental Protection Agency (EPA) studies show that the levels of pollutants in indoor environments can be between 5 and 100 times greater than outside air. The concentration of CO_2 in external environments may vary according to many factors, including the presence or absence of woodlands, construction, traffic, the season, etc., but in any case indoor air should be ventilated to decrease the concentration of CO_2.

One of the factors that influences indoor CO_2 concentrations is the number of indoor plants. Indoor plants consume carbon dioxide and produce oxygen through photosynthesis [4]. Photosynthesis, however, depends on various environmental factors, such as light and temperature. When the necessary conditions are not met, plants begin respiration, taking O_2 from the environment and replacing it with CO_2.

While plants are the most important component to the oxygen and carbon cycle in nature, they are also important indoors. Plants have both a psychological and physical impact on people since they function both to improve the aesthetics of a space and to improve air quality. The concentration of CO_2 in the indoor atmosphere, however, and the amount that plants change this concentration, is not well known.

In 2013, Kastamonu University carried out a research project titled "Plants of Indoor Air Quality in the Classroom Assisted Increasing Opportunities," in order to determine the effect of plants on CO_2 concentrations in domestic environments. The project found that CO_2 concentrations could change quickly depending on many factors, but this study did not clearly determine the influence of plants on the concentration of CO_2 in domestic environments. Working in isolated environments to get more accurate information is necessary.

The effect of plants on indoor air quality has to be determined based on ambient conditions. Among these conditions, the most important are light and temperature. Temperature control is necessary for human comfort, and indoor spaces are usually kept between 20ºC and 25ºC. This range is also ideal for the growth of plants.

Light levels, however, vary greatly in indoor environments. Unless an environment is artificially illuminated, the quantity of light in that environment

changes depending on time of day. Such changes affect plant metabolic activities and thereby influence a plant's effect on indoor CO_2 concentrations.

Plants can be used effectively to regulate the amount of carbon dioxide in an indoor environment. The number of studies on this issue, however, is rather limited. This study aims to determine the effects of select indoor plants on the concentration of CO_2 in an indoor environment. Specifically, this study attempts to determine the effects of these plants based on the presence of sunlight.

Materials and Methods

Five species of common indoor plants were used for this study: *Ficus elastica*, *Yucca massengena*, *Ocimum basilicum*, *Sinningia speciosa*, and *Codiaeum variegatum*. Of these plants, *Ficus elastica* and *Yucca massengena* can reach considerable sizes in indoor spaces. *Ocimum basilicum* and *Sinningia speciosa* are often grown in indoor spaces for their scent and showy flowers, respectively.

The glass-walled compartment used in the study was positioned in a way that prevented direct sunlight but that provided an illuminated environment. Most indoor plants prefer illuminated environments that are not exposed to direct sunlight, and many indoor plants are grown in spaces that have these characteristics. The plants used in this study were placed in an airtight compartment with a glass wall that had a volume of approximately 0.5 m^3 (0.7 m x 0.7 m x 1 m). The measurements of CO_2 within the compartment were carried out via Extech Desktop Indoor Air Quality CO_2 Datalogger, and the CO_2 measuring device placed in the compartment was set to measure CO_2 once every five minutes. The plants used in the study were placed in the compartment between 13:00 and 14:00, and the CO_2 amount inside the space was raised.

During the time of this study, local sunrise was at around 05:05 and sunset at around 20:30. The measurements obtained at around 05:30 were included in the evaluation, and 28-hour measurement results were used in order to better determine the change in CO_2 in one day. Accordingly, the plants were kept in the glass compartment for nearly 45 hours, but only the data obtained during the 28-hour period were used in the evaluation.

Before the study, the plants were watered routinely once per week, and the experiment was held one day after irrigation. In addition to routine maintenance, plants were given a liquid manure fertilizer (specifically for indoor plants) every two weeks in two separate waterings. All plants were set in peat soil.

Results

The Effect of *Ficus elastica* on CO_2 Concentrations

The change in CO_2 concentrations caused by *Ficus elastica* over time is given in Fig. 1. As seen in
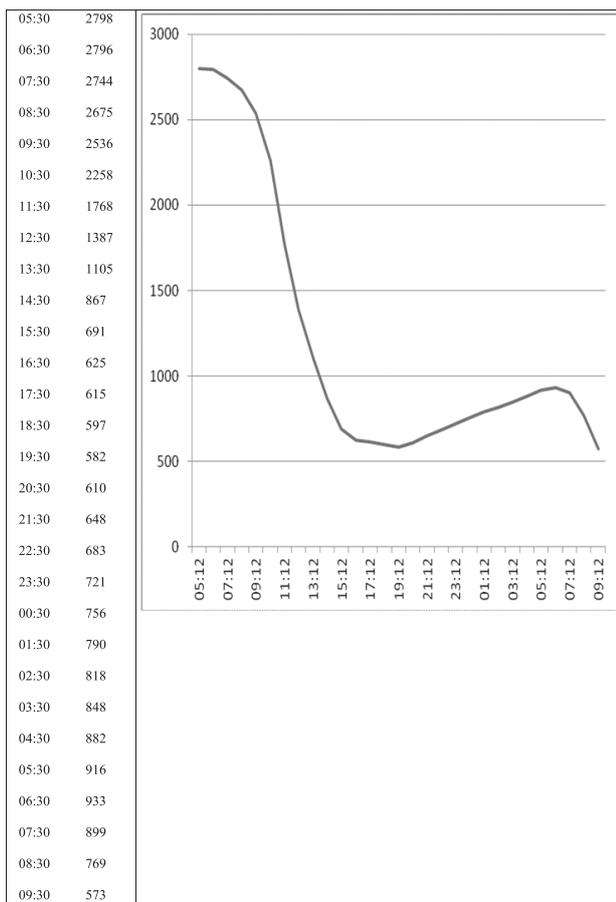
Time	ppm
05:30	2798
06:30	2796
07:30	2744
08:30	2675
09:30	2536
10:30	2258
11:30	1768
12:30	1387
13:30	1105
14:30	867
15:30	691
16:30	625
17:30	615
18:30	597
19:30	582
20:30	610
21:30	648
22:30	683
23:30	721
00:30	756
01:30	790
02:30	818
03:30	848
04:30	882
05:30	916
06:30	933
07:30	899
08:30	769
09:30	573

Fig. 1. Change in CO_2 amount created by *Ficus elastica* in the course of time.

Time	ppm
05:30	3310
06:30	3249
07:30	3052
08:30	2687
09:30	2380
10:30	2028
11:30	1768
12:30	1518
13:30	1273
14:30	1087
15:30	960
16:30	855
17:30	786
18:30	740
19:30	732
20:30	749
21:30	780
22:30	810
23:30	861
00:30	891
01:30	929
02:30	959
03:30	989
04:30	1016
05:30	1042
06:30	1036
07:30	984
08:30	822
09:30	679

Fig. 2. Change in CO_2 amount created by *Yucca massengena* in the course of time.

Fig. 1, *Ficus elastica* had a measurable effect on the CO_2 concentrations in the test area. The CO_2 concentration did not change significantly until around sunset, at which time CO_2 increased until sunrise. The CO_2 concentration, which started at 2,798 ppm at 05:30, fell to 2,796 ppm by 06:30. The CO_2 concentration then decreased rapidly to 625 ppm by 16:30 and 582 ppm by 19:30. At this point, the concentration of CO_2 began to increase, rising to 933 ppm by 6:30 on the following day. The CO_2 concentration fell again after this point. In a 24-hour period, the CO_2 concentration in the air decreased from 2,798 ppm to 933 ppm. The CO_2 concentration fell 2,216 ppm during the day and rose 351 ppm during the night. Therefore, it can be said that during the day, *Ficus elastica* consumes approximately 6.3 times as much CO_2 as it produces at night.

The Effect of *Yucca massengena* on CO_2 Concentrations

The change in the CO_2 concentration caused by *Yucca massengena* over time is given in Fig. 2. In the case of *Yucca massengena*, the CO_2 concentration in the air was 3,310 ppm at the beginning of the study period, and the concentration fell rapidly until reaching 855 ppm at around 1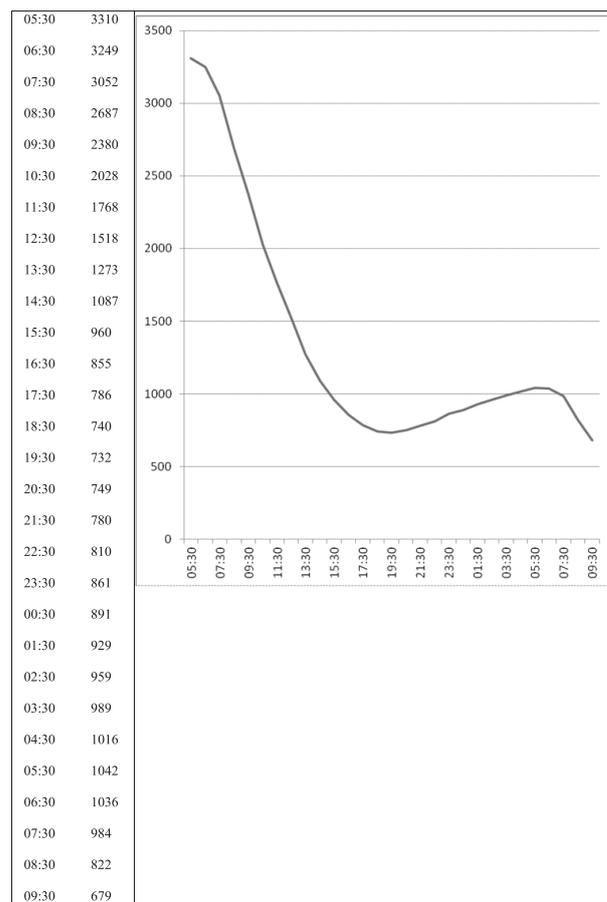6:30. The pace of this decline in CO_2 decreased at this point, reducing the CO_2 concentration further to 732 ppm, which was its lowest level, at 19:30. The CO_2 concentration began to increase at 19:30. This increase continued until 05:30, at which time the CO_2 concentration was 1,042 ppm. The CO_2 concentration, which was 3,310 ppm at 05:30, decreased to 732 ppm at 19:30. Thus a decrease of 2,578 ppm took place during the daytime. The CO_2 concentration started to increase again at 19:30 and became 1,042 ppm by 05:30 the next morning. In other words, a rise of 310 ppm occurred during the night. The CO_2 concentration decreased a total of 2,268 ppm in 24 hours. The decrease in the CO_2 concentration during the day was approximately 8.3 times greater than the increase during the night.

The Effect of *Ocimum basilicum* on CO_2 Concentrations

The change in the CO_2 concentration caused by *Ocimum basilicum* over time is given in Fig. 3. The CO_2 concentration started at 1,565 ppm and decreased little until 09:30. The CO_2 concentration then underwent a rapid fall, however, decreasing to 1,198 ppm at 12:30. This rapid decrease ended at 12:30, after which time the CO_2 concentration decreased to 1,148 ppm by 16:30. After this point, the CO_2 concentration followed a
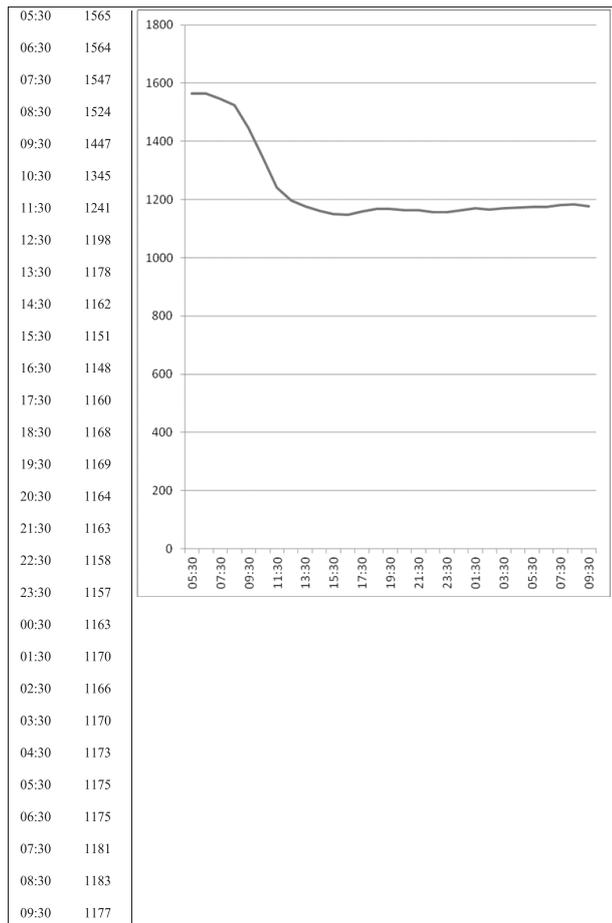
Time	Value
05:30	1565
06:30	1564
07:30	1547
08:30	1524
09:30	1447
10:30	1345
11:30	1241
12:30	1198
13:30	1178
14:30	1162
15:30	1151
16:30	1148
17:30	1160
18:30	1168
19:30	1169
20:30	1164
21:30	1163
22:30	1158
23:30	1157
00:30	1163
01:30	1170
02:30	1166
03:30	1170
04:30	1173
05:30	1175
06:30	1175
07:30	1181
08:30	1183
09:30	1177

Fig. 3. Change in CO_2 amount created by *Ocimum basilicum* in the course of time.

Time	Value
05:30	2583
06:30	2579
07:30	2559
08:30	2511
09:30	2405
10:30	2211
11:30	1998
12:30	1922
13:30	1889
14:30	1873
15:30	1867
16:30	1865
17:30	1858
18:30	1865
19:30	1876
20:30	1892
21:30	1905
22:30	1932
23:30	1959
00:30	1982
01:30	2000
02:30	2024
03:30	2041
04:30	2053
05:30	2076
06:30	2091
07:30	2074
08:30	2029
09:30	1901

Fig. 4. Change in CO_2 amount created by *Sinningia speciosa* in the course of time.

horizontal course. With little increase in total, it went up to 1,175 ppm by 05:30 and to 1,183 ppm by 08:30. These results indicate that the CO_2 concentration went through a rapid decrease between 09:30 and 12:30 but followed an almost horizontal course at other times during the day, though it did continue to decrease slightly. The CO_2 concentration, which was 1,164 ppm at 20:30 at night, increased to 1,175 ppm by 05:30 the next morning. Thus it increased only 11 ppm in total. The CO_2 concentration decreased 401 ppm between 05:30 and 20:30 during the daytime. Of the 401 ppm decrease, the concentration of CO_2 decreased 206 ppm between 09:30 and 11:30. This period represents the time that the environment containing *Ocimum basilicum* was the hottest and most illuminated.

The Effect of *Sinningia speciosa* on CO_2 Concentrations

The change in CO_2 concentration caused by *Sinningia speciosa* over time is given in Fig. 4. As shown in Fig. 4, the CO_2 concentration was 2,583 ppm at 05:30 in the environment containing *Sinningia speciosa*, and this concentration decreased until 17:30, at which point it was at 1,858 ppm. The CO_2 concentration started to increase after this point and reached 2,091 ppm at 06:30.
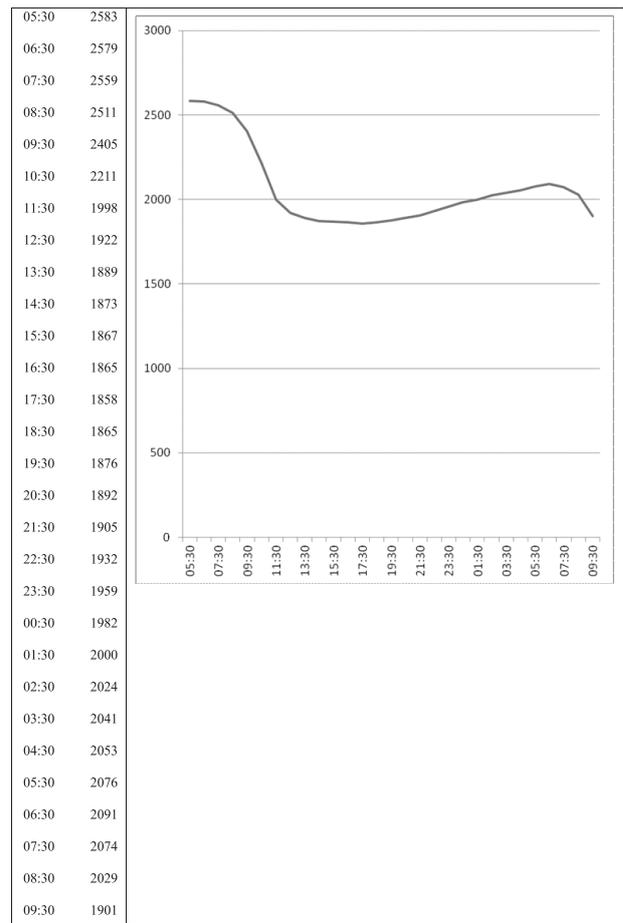
These figures clearly show that when the amount of light decreases in the environment containing *Sinningia speciosa,* photosynthesis stops and respiration starts. The CO_2 concentration fell 725 ppm in total during the day, decreasing from 2,583 ppm to 1,858 ppm. However, the concentration increased to 2,076 ppm from 17:30 to 05:30, a rise of 218 ppm. The decrease in the concentration of CO_2 during the day was only 3.3 times greater than the increase at night. The total reduction in the CO_2 concentration over the 24-hour period was 507 ppm.

The Effect of *Codiaeum variegatum* on CO_2 Concentrations

The change in the CO_2 concentration caused by *Codiaeum variegatum* over time is given in Fig. 5. In the case of *Codiaeum variegatum*, the CO_2 concentration began at 1,861 ppm at 05:30 and decreased to 1,071 by 19:30. The concentration of CO_2 then increased to 1,155 ppm by 05:30 the next morning. In other words, the CO_2 concentration fell 790 ppm during the day and increased 84 ppm during the night. The amount of CO_2 consumed during the day was approximately 9.4 times greater than the amount of CO_2 given off at night.
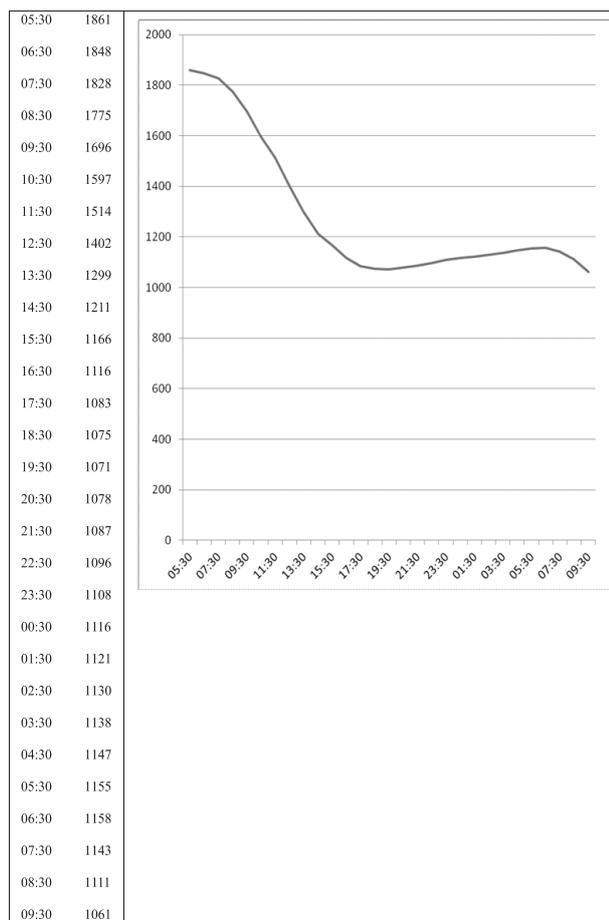
05:30	1861
06:30	1848
07:30	1828
08:30	1775
09:30	1696
10:30	1597
11:30	1514
12:30	1402
13:30	1299
14:30	1211
15:30	1166
16:30	1116
17:30	1083
18:30	1075
19:30	1071
20:30	1078
21:30	1087
22:30	1096
23:30	1108
00:30	1116
01:30	1121
02:30	1130
03:30	1138
04:30	1147
05:30	1155
06:30	1158
07:30	1143
08:30	1111
09:30	1061

Fig. 5. Change in CO_2 amount created by *Codiaeum variegatum* in the course of time.

Discussion

This study found that all of the selected plants reduced the CO_2 concentration to a certain extent during the day. The CO_2 concentration decreased 2,216 ppm in the case of *Ficus elastica*, 2,578 ppm in the case of *Yucca massengena*, 401 ppm in the case of *Ocimum basilicum*, 725 ppm in the case of *Sinningia speciosa*, and 790 ppm in the case of *Codiaeum variegatum*. *Ficus elastica* and *Yucca massengena* both considerably reduced the concentration of CO_2 in the air. *Sinningia speciosa* and *Ocimum basilicum*, on the other hand, had less of an effect on the CO_2 concentration in the environment. These results were not surprising. While *Ficus elastica* and *Yucca massengena* are large indoor plants, *Sinningia speciosa* and *Ocimum basilicum* are smaller plants grown for their scent and flowers. The effect on the CO_2 concentration was directly proportional to size. Although *Codiaeum variegatum* is a large plant, it had a limited effect on the CO_2 concentration. That may be due to the anatomic structure of the plant. According to Kacar et al., [8] some plant leaves are thick and make less use of light. That may be true for *Codiaeum variegatum*, but the *Ficus elastica* used in this study had a significant effect on the CO_2 concentration in the environment despite having a thick leaf structure. Therefore, the effectiveness of the plant at reducing CO_2 concentrations may be due to the chlorophyll content in the leaves. The colors of the leaves of these two plants are noticeably different: the *Ficus elastica* has dark green leaves, but the *Codiaeum variegatum* has leaves containing various tones besides green, including yellow, red, and orange. The coloration of plants is determined by pigments that are categorized as chlorophylls, carotenoids, phycobilins, flavonoids, betalains, and betacyanins [9]. Among these pigments, chlorophyll provides plants with green color and enables photosynthesis [5]. Accordingly, the color of a plant's leaves indicates the quantity of chlorophyll, and the quantity of chlorophyll is one of the most important factors influencing photosynthesis.

Another remarkable finding of the study is that *Codiaeum variegatum*, *Ficus elastica*, and *Yucca massengena* reduced the concentration of CO_2 even when the light level was low. *Sinningia speciosa* and *Ocimum basilicum*, on the other hand, either did not change the quantity of CO_2 in the environment or actually increased it. This result may be due to the anatomic structures of the plants used in the study. According to Kacar et al., [8] the amount of light needed for photosynthesis may vary by plant species. They report, for example, that photosynthesis in *Asarum caudatum* reaches its peak when the quantity of light is 200 μmol m^{-2}s^{-1}, while photosynthesis in *Atriplex triangularis* reaches its peak when the quantity of light is 1,700 μmol m^{-2}s^{-1}.

The amount of CO_2 consumed by the plants during the day was determined to be much more than the amount of CO_2 produced by them at night. Since *Ocimum basilicum* had a limited effect on the increase in the CO_2 concentration during the night, it was excluded from the calculation. The concentration of CO_2 consumed by the plants (other than *Ocimum basilicum*) during the day ranged from 3.3 to 9.4 times the amount of CO_2 produced by them at night.

As living organisms, plants require various conditions in order to survive. Additionally, they change ambient conditions through their metabolic activities. When ambient conditions are suitable for plant growth, they emit oxygen into the environment and absorb carbon dioxide from the environment, but the opposite is true when conditions change [8, 10]. One study on this subject concluded that the concentration of CO_2 in forestland is on average 391 ppm during the day and 422 ppm during the night in winter months, but it is on average 148 ppm during the day and 229 ppm during the night in summer months [10].

Though plants are used for aesthetic purposes in landscaping, the fact that they affect the concentration of CO_2 in the environment is well known [11]. Previous research reports that a beech tree that has a leaf surface of 1,600 m^2 can meet the oxygen needs of 10 people [4]. According to Tarran et al., [12] the existence of plants reduces the concentration of CO_2 by 10% in offices with an air-conditioner and by 25% in those with natural ventilation.

Studies on indoor plants have determined that the effect on the concentration of CO_2 in the environment is

significant. When considering plants of equal size in 1 m^3 of air at 25ºC, *Dieffenbachia amoena* decreased the CO_2 concentration by 480 ppm in one hour, while *Spathiphyllum floribundum* decreased the CO_2 concentration by 393 ppm, *Ficus benjamina* decreased the CO_2 concentration by 315 ppm, and *Yucca elephantipes* reduced the concentration by around 93 ppm [13]. In another study that identified how much the concentration of CO_2 was reduced during the day among plants in equal atmospheric conditions, *Schefflera arboricola* reduced the concentration of CO_2 by 1,252 ppm, *Fuchsia magellanica* reduced the concentration of CO_2 by 252 ppm, and *Ficus benjamina* reduced the concentration of CO_2 by 657 ppm [14].

Research should be carried out with different plants with the aim of discovering plants that photosynthesize faster in indoor environmental conditions. Another issue to be researched is how to increase the photosynthesis rates of plants by changing indoor conditions. Intensity of light and type of light, for instance, should be the subject of research because the effect of plants on indoor air quality depends on photosynthesis. Previous research has shown that green plants photosynthesizing in adequate light conditions not only reduce the concentration of CO_2 in the environment [12, 15], but they also decrease sulfur content [16] and improve air quality by filtering pollutants that are harmful to living beings (e.g., dust, ash, pollen, smoke, and particulate matter) [17, 18]. Moreover, some studies have been conducted on the effects of plants in this regard [12, 13, 19]. Research in this field, however, should be increased and provide details that enable the practical use of plants to reduce CO_2 concentrations in indoor spaces.

Conclusions

The findings of the present study offer important clues for choosing plants based on the characteristics of the environment and the time spent in the environment. For example, *Ficus elastica* and *Yucca massengena* considerably reduce the concentration of CO_2 during the day, but substantially increase it during the night, relative to other plants. The use of these plants in places that are primarily occupied during the day, such as offices, classrooms, and shopping malls, may be beneficial. Codiaeum variegatum and Ocimum basilicum, however, which produce less CO_2 at night, should be preferred in environments that are mostly used at night, such as houses, dormitories, and hotels. Likewise, the light received by the environment in which the plant is kept affects its ability to reduce the concentration of CO_2. While *Sinningia speciosa* and *Ocimum basilicum* either do not change or just increase the concentrations of CO_2 in the environments where the intensity of light is low, *Ficus elastica*, *Codiaeum variegatum*, and *Yucca massengena* reduce the concentrations of CO_2 in their environments even when the intensity of light is low. Therefore, these plants will be better used in environments where the intensity of light is inadequate for other plants. As stated before, however, research on this subject is not sufficient, and such research should be increased and offer more details so that plants can be effectively used to reduce the concentrations of CO_2 in indoor spaces.

References

1. CETIN M. Evaluation of the sustainable tourism potential of a protected area for landscape planning: a case study of the ancient city of Pompeipolis in Kastamonu. Int. J. Sust. Dev. World. **22** (6), 490, doi: 10.1080/13504509.2015.1081651, **2015**.
2. KONIJNENDIJK C.C. A decade of urban forestry in Europe. Forestry Policy and Economics. **5** (2), 173, **2003.**
3. SEVIK H., KARAKAS H., SENOZ E. Evaluation of air quality in terms of the amount of carbon dioxide in black sea region. International Journal of Engineering Science & Research Technology. **2** (2), 805, **2013**.
4. CETIN M. Determining the bioclimatic comfort in Kastamonu city. Environ. Monit. Assess. **187** (10), 640, **2015**.
5. SEVIK H., KARAKAS H., KARACA U. Color - Chlorophyll relationship of some indoor ornamental plant, International Journal of Engineering Science & Research Technology, **2** (7), 1706, **2013**.
6. BULGURCU H., ILTEN N., COSGUN A. Indoor air quality problems and solutions in schools. Journal of Installation Engineering. **96**, 59, **2006** [In Turkish].
7. ERCAN M.S. Your compass green "Environmental Indicator". X. International HVAC Technology Symposium, 169, 30 April-May, 2012, Istanbul, Turkey, **2012** [In Turkish].
8. KACAR B., KATKAT V., OZTURK S. Light, plant physiology. The Nobel Broadcast Distribution, Ankara, 270, **2010** [In Turkish].
9. KARAKURT H., ASLANTAS R. Plant material of color (pigment) formation and changes in physiology, Alatarım. **7** (2), 34, **2008** [In Turkish].
10. SEVIK H., CETIN M., BELKAYALI N. Effects of forests on amounts of CO_2: case study of Kastamonu and Ilgaz Mountain National Parks. Pol. J. Environ. Stud. **24** (1), 253, **2015**.
11. CETIN M. Using GIS analysis to assess urban green space in terms of accessibility: case study in Kutahya. Int. J. Sust. Dev. World. **22** (5), 420, **2015**.
12. TARRAN J., TORPY F., BURCHETT M. Use of Living Pot-Plants to Cleanse Indoor Air-Research Review, Proceedings of Sixth International Conference on Indoor Air Quality, Ventilation & Energy Conservation in Buildings-Sustainable Built Environment, **3**, 249, **2007**.
13. SEVIK H., CETIN M., BELKAYALI, N., GUNEY, K. The effect of some indoor plants of the amount of CO_2 in the internal environment. The result of TUBITAK 3001 project. Project number 114Y033. **2015** [In Turkish].
14. SEVIK H., CETIN M., ISINKARALAR K. Effects of some indoor ornamental plants on the amount of indoor Carbondioxide. Duzce University. The Journal of Science and Technology. In press. **2015** [In Turkish].
15. TURK M., CELIK N. Determination of CO_2 assimilation in C-3 and C-4 type of photosynthesis in plants respiratory equilibrium. Suleyman Demirel University, Journal of Science Institute, **10** (1), 48, **2006**.
16. ATAYETER Y. An assessment of the air pollution in the city of Burdur, I. Burdur Symposium. 635, 16-19 November, Burdur, Turkey, **2007**.

17. ONDER S., AKBULUT C.D. Evaluation of urban green areas, open-used plant materials; an example of the city of Aksaray. Journal of Selcuk Agriculture and Food Science, **25** (2), 93, **2011**.

18. YILMAZ S., BULUT Z., YESIL P. The benefits of the urban forest in the urban space. Ataturk University, Journal of Faculty of Agriculture. **37** (1), 131, **2006**.

19. SEVIK H., KANTER I. The effect of indoor plants on indoor air quality. X. International HVAC Technology Symposium, Proceedings, 517, 30 April-02 May, 2012, Istanbul, Turkey, **2012**.