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Original Research

Ability of the Hibiscus Plant to Absorb Carbon Dioxide Gas in Summer and Its Effect on Plant Pigments

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Abstract:

The plants (*H. tiliaceus*) were exposed to gaseous pollutants CO_2 and under controlled conditions represented by a greenhouse. The physiological changes of the plants were observed through equal time periods daily for a period of seven days. The process was repeated three times between the three exposures provide rest periods for the plant for a week. During summer exposure, it was found that the removal rate for plant *H. tiliaceus* 78.7%, during the exposure period. During summer exposure *H. tiliaceus* after the second and third exposure to CO_2, whereas this concentration was decreased from 3.12 to 2.36 mg/g after the third exposure. The concentration of chlorophyll B was significantly decreased after the secondexposure of *H. tiliaceus* to CO_2 from (4.93) to (1.91) mg/g, but this concentration was increased after the third exposure into 3.95 mg/g. There was no significant decrease in carotenoid concentration after the second exposure (with concentration 1.35 mg/g), but this concentration was returned decreased significantly to 2.8 mg/g after the third exposure to CO_2.

Keywords: Global Warming, Greenhouse gases, Phytoremediation, Air phytoremediation (AP), pigments' plant, Chlorophyll - *H. tiliaceus*,

Introduction

The term "climate change" is commonly used to refer to the effects of global warming on Earth's climate system. (Ahmed, 2020). Historically significant shifts in Earth's climate are included in a broader definition of "climate change." (Helldén *et al.*, 2021). Increasingly rapid increases inglobal average temperature can be traced back to human activity, specifically the combustion of fossil fuels (Holechek *et al.*, 2022). Greenhouse gases, such as carbon dioxide and methane, are on the rise due to human activities like burning fossil fuels,cutting down trees, and certain agricultural and industrial processes (Raihan and Tuspekova, 2022). In response to the sun's warming effect, the Earth emits heat, some ofwhich is absorbed by greenhouse gases. Increases in these gas concentrations are a major contributor to global warming (vanWijngaarden and Happer, 2023).

Climate change is causing an increase in the frequency of heat waves and wildfires,and the spread of deserts (Pausas and Keeley,2021). The melting of permafrost, the retreatof glaciers, and the disappearance of sea ice are all results of the

Arctic's rising temperature (Moon *et al.*, 2019). Increases in temperature are also contributing to the intensification of storms, droughts, and other climate extremes (Decuyper *et al.*, 2020). Many species are being displaced or going extinct as a direct result of fast environmentalalternation in mountain ranges, the Arctic andcoral reefs (Makau, 2022). Some effects will persist for centuries even if future warming ismitigated. Among these are the effects ofocean warming, acidification of ocean, and increase of sea level (Garcia-Soto *et al.*, 2021a).

Food and water shortages, extreme heat, flooding, new diseases, and economic losses are just some of the consequences of climate change that pose a threat to humanity.In addition, human migration and war may follow (Jones, 2022). According to WHO, climate change is one of the most pressing issues facing global health in the 21stcentury. (Benjamin, 2020). Without action to limit warming, societies and ecosystems willbe exposed to greater risks in the future (Hobbie and Grimm, 2020). Risks associatedwith climate change can be mitigated by taking measures to adapt to it, such as constructing flood barriers or planting drought-resistant crops. However, this may become impossible as the planet continues to warm. Though they contribute comparativelylittle to global emissions, developing nations are particularly vulnerable to the effects of climate change because they lack the resources to adapt (Pauw *et al.*, 2020).

Already, at a warming of only 1.2 °C (2.2 °F), many adverse effects of climatechange are being felt. The melting of the Greenland ice sheet, for example, is one consequence of climate change that could be exacerbated by further warming (Pörtner *et al.*, 2022). Individual nations also committed to keeping global warming "well under 2 °C" under the Paris Agreement of 2015. A warming of about 2.7 °C (4.9 °F) by the end of the century is still possible even with the commitments made under the Agreement. For a 1.5 °C temperature rise cap to be maintained, emissions must be cut in half by2030 and and net-zero by 2050 (BEQIRI & HALILI, n.d.).

Table 1: The gas content of the earth's atmosphere Al-Ghussain, 2019)

Gas name	Percentage (%)
Ozone	0.00001
Nitrogen oxide	0.000078
Methane	0.000442
Helium	0.001299
Neon	0.004675
Carbon dioxide	0.0935
Argon	0.9
Oxygen	21
Nitrogen	78

Table 1 shows the relative amounts of various gases, such as greenhouse gases and pollutants, that make up Earth's atmosphere. While the percentages of the three mainstay gases (N2, O2, and Ar) remain constant, thoseof the trace gases (CO_2, CH_4, and NO_x) fluctuate on a daily, seasonal, and annualbasis. Unlike the other main components of the atmosphere, GHGs can absorb andreradiate infrared radiation because their atoms have internal vibrational modes. (Al- Ghussain, 2019). As the Earth's surface is heated by the sun through the atmosphere, greenhouse gases are responsible. Infrared radiation from the Earth is partially absorbed by greenhousegases. By reducing the rate at which heat canescape into space, this absorption eventually warms the planet by trapping heat near its surface (Stallinga, 2019). The surface air wasabout 33 degrees Celsius warmer before the Industrial Revolution due to the presence of naturally occurring amounts of greenhouse gases (Ali, 2021). The largest contributors to the greenhouse effect are clouds (25%) and water vapour (50%), both of which increase as a function of temperature and are thus feedbacks (Gjermundsen *et al.*, 2021). The concentrations of gases like carbon dioxide (20%), nitrous oxide, chlorofluorocarbons (CFCs) and tropospheric ozone, are external forcings because they are not temperature dependent. (Arosio *et al.*, 2019).Greenhouse gases have increased in theatmosphere as a result of human activity since the Industrial Revolution, primarily the extraction and burning of fossil fuels (naturalgas, oil and coal). This has led to a radiative imbalance. (Siddik et al., 2021). Increases incarbon dioxide (48%) and methane (160%) concentrations were observed in 2019 compared to 1750.(J. Tan *et al*., 2023). The current $CO2$ levels are the highest they have been in at least two million years. Methane levels are significantly higher than they havebeen for the past 800,000 years. (Chen *et al.*,2020).

Phytoremediation technologies useliving plants to clean up soil, air and water contaminated with hazardous contaminants (Anand et al., 2023; Yadav & Kumar, 2019). The term refers to the practice of utilising green plants and their accompanying microbes, in conjunction with suitable soil amendments and agronomic approaches, to control, eliminate, or neutralise harmful environmental toxins (Kumari et al., 2022). The word isa combination of the Greek phyto (plant) and the Latin remedium (treatment) (restoring balance). cost-effective though it may be, phytoremediation has not been shown to solve any major environmental problem by reclaiming previously polluted land (Adeoyeet al., 2022).

The capacity of plants to concentrate elements and compounds from the environment and to detoxify diverse substances has led to the proposal of phytoremediation as a cost-effective plant- based method to environmental cleanup. Plants with the hyperaccumulator trait are able to bioaccumulate substances, which causes them to accumulate in the plant. Remediation has a very distinct impact. Phytoremediation often focuses on organic contaminants rather than inert heavy metals since they may be destroyed. The effectiveness of employing plants forpollution control has been shown in many field studies (James, 2022).

To clean up contaminated air, scientistsdeveloped a technique called air phytoremediation (AP), which employs the utilization of plants to absorb and degrade harmful substances. Due to their capacity to ingest, digest, or alter airborne toxins into less hazardous ones, some plants may facilitate the removal of airborne pollutants using AP technology. Several studies have shown that plants can filter out harmful substances from the air. Spinacia oleraceaand Brassica oleracea absorb Cd, Sn, Zn, andPb from air particles via their leaves;Chenopodium murale removes volatilehydrocarbons; Zea mays removes phenolic compounds; and Zamioculcas zamiifolia removes formaldehyde, all of which are present in polluted air (S. Kumar *et al.,* 2019; B. Zhang *et al.*, 2020).

The current study aims: Reducing some greenhouse gases and air pollutant impact. Thus, reducing the rate of temperature rise. Also, to preserve the aesthetics of the area by increasing the range of green areas. And the non-desertification of the area by planting the trees of these plants.

Materials and Methods Collection of samples

Six-months-saplings of plant *Hibiscus tiliaceus* were obtained from Barakat Al-Zahra'a nursery zowhur nursery in Babel city and Howat Al- by planting the trees of these plants. From (3/5 to 7/6 /2023)

Design of the study

The study was performed as a randomized complete design (RCD) whereas three replicates or blocks were prepared for plant, *Hibiscus Tiliaceus*, during summer seasons. Each plant replicate was exposed to carbon dioxide (CO_2). Each plant was exposed to gas for three separated weeks (there were rested week after each exposure week). whereas each room (2 m^3) were covered by polyethylene with dimensions (0.5 * 2 * 2 m). The plant in each house was exposed into gas CO_2, as follows: replicates were contained 3000 ppm of CO_2.

The bottle of CO_2 was obtained from Dur Al-Hussam company, while methane gas bottle was obtained from Baghdad office for artificial gases.

Gas CO_2 were assessed using probes :for CO_2 (400 – 5000 ppm) (MHZ19B company). The following diagram (3-1) was showed the randomized compete block design of the current study:

Figure 1. study plant

Figure 2. plant exposed to CO_2 gas

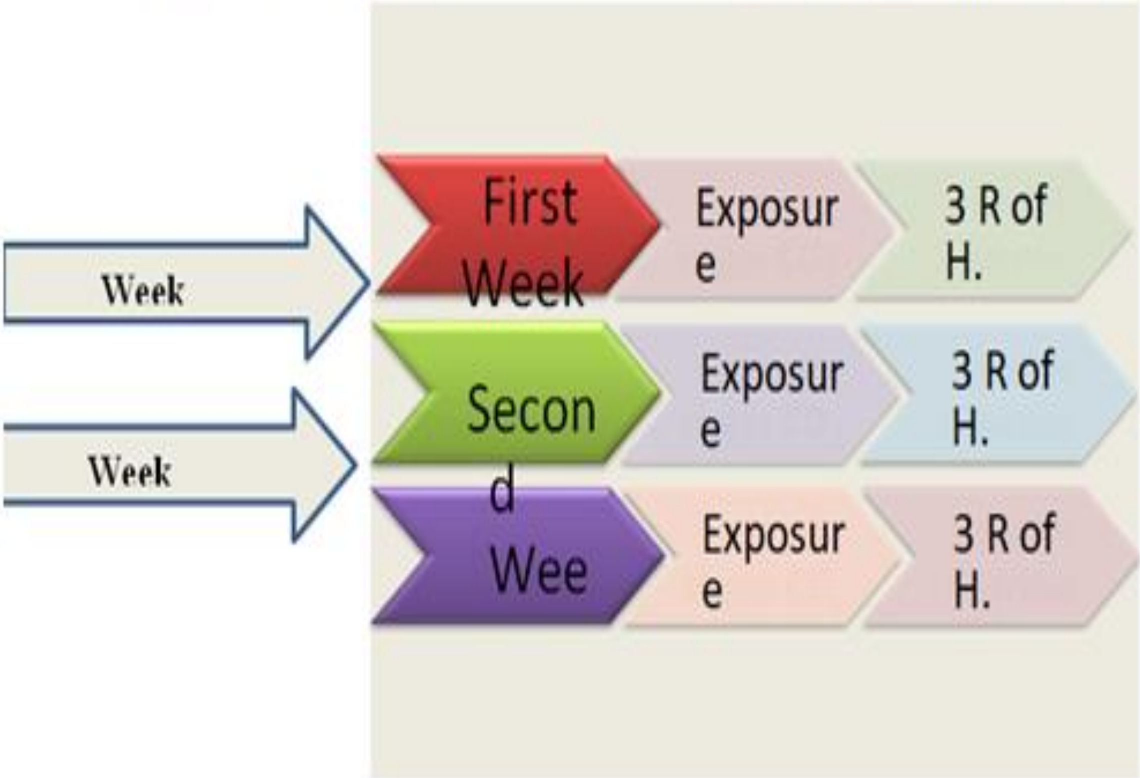


Figure 3. The design of study, R: : replicate.

Physiological growth indexes

After each week during study, sample of leaf from each plant was obtained and examined using the following tests:

Chlorophyll A and B concentration

A 1 g of plant tissue (soft leaf) was cut into small pieces then crushed using ceramic mortar with addition of 10 ml of 80% acetone in order to extract the chlorophyll pigment. The obtained mixture was placed in glass test tube for 20 hours in refrigerator (4 ^{o}C) in dark place. Then the tube was mixed and left for 1 to 2 hours at same conditions. The volume was completed into 50 ml by addition of distill water then the tube was centerfugated at 3000 rpm for ten minutes. One to two drops of hydrochloric acid (0.1 N) were added into tube for filtration of mixture. The absorbance of filtrate was calculated utilizing spectrophotometer at 663 to 645 nm. The chlorophyll concentration was counted as follows (Parry *et al.*, 2014):

$$Chlorophyll\ a\ \ mg\square g\square\square = \ \ 12.7\ A\square663\square - 2.69\ A\square645\square\square a$$
$$\times 1000\ \times w\square\ \times$$

$$Chlorophyll\ b\ \ mg\square g\square\square = \ \ 22.9\ A\square645\square - 4.68\ A\square663\square\square a\ \times$$
$$1000\ \times w\square\ \times$$

$$Total\ Chlorophyll\ \ mg\square g\square\square = \ \ 20.2\ A\square645\square - 8.02\ A\square663\square\square a\ \times$$
$$1000\ \times w\square\ \times$$

Where:

- W: Sample fresh weight in gram
- V: The extract volume in milliliter.
- A: Light path length in cell (1 centimeter).

Carotenoid concentration

A 1 g of plant tissue (soft leaf) was cut into small pieces then crushed using ceramic mortar with addition of 10 ml of 80% acetone in order to extract the chlorophyll pigment. The obtained mixture was placed in glass test tube for 20 hours in refrigerator (4 ^{o}C) in dark place. Then the tube was mixed and left for 1 to 2 hours at same conditions. The volume was completed into 50 ml by addition of distill water then the tube was centerfugated at 3000 rpm for ten minutes. One to two drops of hydrochloric acid (0.1 N) were added into tube for filtration of mixture. The optical density of filtrate was calculated using spectrophotometer at 452 nm. The concentration of carotenoid was counted as the following formula:

$$Carotenoid\ \ mg\square g\square\square = \ \ 1000\ A\square452\square - Chl\ a\ \times 1.82 - Chl\ b\ \times$$
$$85.02\square\square 1000\ \times w\square\ \times V\ \times 198$$

Where:

- A: absorbance
- V: final volume of the extract (50 ml).
- W: weight of plant leaves (1 g)

Results and Discussion:

During summer exposure, it was found from table (2) that the removal rate for plants *H. tiliaceus* was 78.7%, during the exposure period.It was found that the highest removal rate was from *H. tiliaceus* plants in Second exposure (82.9%), perhaps due to its leaves having a larger surface area.

Table 2. Percentage removal in summer exposure.

Exposure	Plant	Average the first exposure	Average the second exposure	Average the third exposure	Average
Summer	*H. tiliaceus*	73.5 %	82.9%	79.8 %	78.7 %

Through summer exposure, we find the highest removal rate was from plants *H. tiliaceus*, perhaps due to its leaves having a larger surface area (Figure 4). This agreed with (Daud, M et al., 2019) A study was carried out to determine the ability of seven different tree species prevalent in urban forests to absorb carbon dioxide.

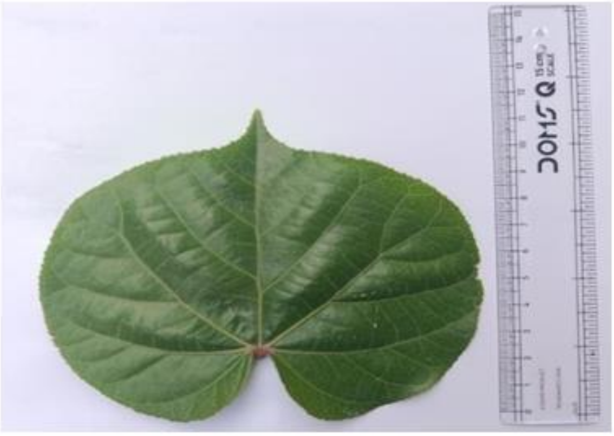


Figure 4. Surface area of study plants

Terminalia catappa had the maximum carbon dioxide absorption rate per leaf per hour (0.511 g/leaf/hour), whereas Calophyllum inophyllum had the lowest (0.056 g/leaf/hour). This is attributed to the fact that the plant was exposed to constant stress as a result of the closed environment, while Plant in an open environment, as stress in the external environment is less than in a greenhouse. We notice from figure (5,6 and 7) the effect of humidity and temperature rise over exposure, affecting the absorption of carbon dioxide and the process of photosynthesis, and this is consistent with Morphological and physiological adaptations play a crucial role in plant defense against air pollutants and greenhouse gases. For example, plants exposed to elevated CO_2 levels may exhibit increased leaf thickness and reduced stomatal density, which can help to reduce water loss and maintain photosynthetic efficiency under drought conditions (Ainsworth & Rogers, 2007). Additionally, plants can adjust their photosynthetic machinery to optimize carbon fixation and light utilization in response to fluctuating CO2 and light conditions (Flexas et al., 2016). Suppose we want to limit these pollutants' detrimental impacts on plant antioxidants. In that case, one of the most important strategies we can employ is to reduce greenhouse gas emissions and air pollution. Implementing technology that is cleaner and more efficient in the energy, transportation, and industrial sectors has the potential to drastically reduce the emissions of greenhouse gases and particles that contribute to air pollution.

Maturing the pigments' plant of the studied plants during summer exposure to gas CO2

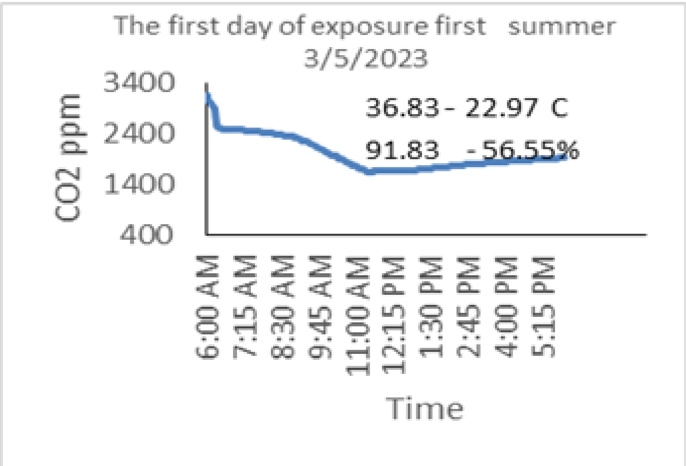
Three physical growth indexes, including chlorophyll A, B and carotenoid pigment, were estimated in the studied plants after the exposure into CO2 Gas during the period of three weeks.

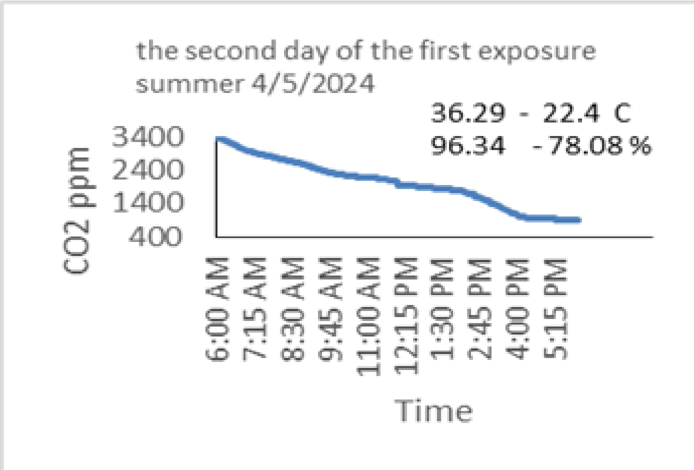
Table 3. Summer exposure to CO_2 gas in three periods and its effect on pigments in of plants.

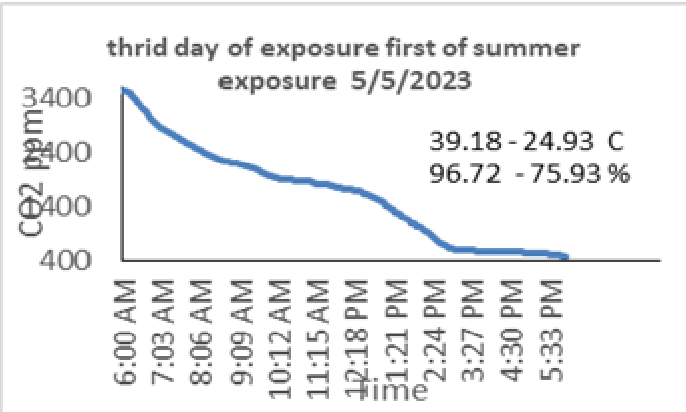
Summer exposureto *H. tiliaceus* to CO_2 gas	Chlorophyll A (mg/g)	Chlorophyll B (mg/g)	B-Carotenoid (mg/g)	Total
First exposure toCO_2 gas	3.12 ab	4.93 ab	2.54 bc	8.05 ab
Second exposure toCO_2 gas	2.87 ab	1.91 c	1.53 cd	4.78 cd
Third exposure toCO_2 gas	2.63 b	3.95 bc	2.8 b	6.58 bc
Control	3.461	6.177	0.7808	9.635

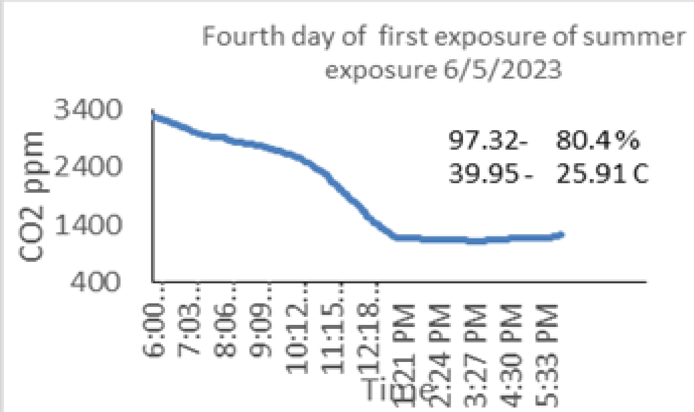
According to the results in table (3) in *H. tiliaceus* after the second and third exposure to CO_2, whereas this concentration was decreased from 3.12 to 2.3-2.673 mg/g after the third exposure. The concentration of chlorophyll B was significantly decreased after the second exposure of *H. tiliaceus* to CO_2 from (4.93) to (1.91) mg/g, but this concentration was increased after the third exposure into 3.95 mg/g. There was no significant decrease in carotenoid concentration after the second exposure (with concentration 1.35 mg/g), but this concentration was returned decreased significantly to 2.8 mg/g after the third exposure to CO_2.

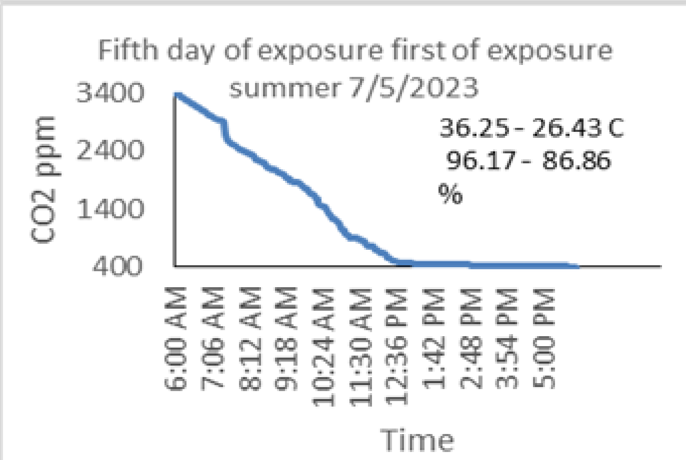
By comparing the results with the control values, we find the pigments when plants are exposed to CO_2 gas, the values were lower than the control, and this is a result of their influence on the exposed gases, and this is consistent with (Yang et al., 2023) The process of photosynthesis relies on pigments that are able to absorb light and convert it into usable energy. Crop growth and production are expected to be influenced by rising atmospheric CO_2 concentrations, which may effect on the plants in many ways. Hence, evaluation in CO_2 lead to enhance the whole-use-efficiency of plant through elevating rate of photosynthesis and reducing transpiration of leaf (Deryng *et al.*, 2016). This effect is predicted to be helpful in alleviating drought stress on crops (Shanker *et al.*, 2022). The evaluation of CO_2 cause increase in the content of carotenoids and chlorophyll a, b; however, it not exhibit any effect on the interactivity of these pigments (Yang *et al.*, 2023). The early stimulation of photosynthesis is diminished and, in many cases, suppressed by long-term (months-long) CO_2 enrichment (Naidoo, 2016)

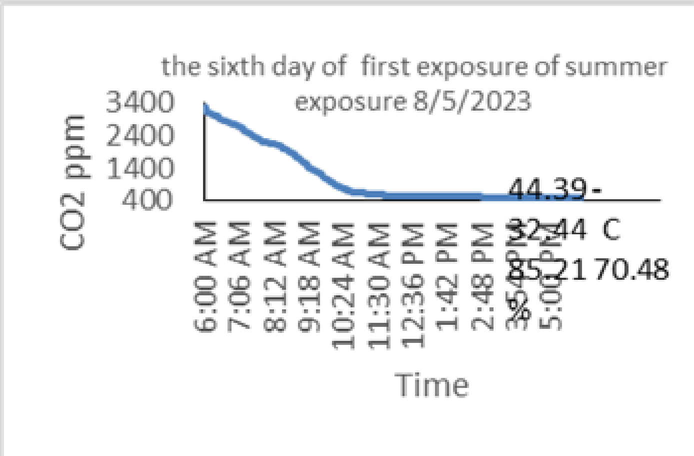












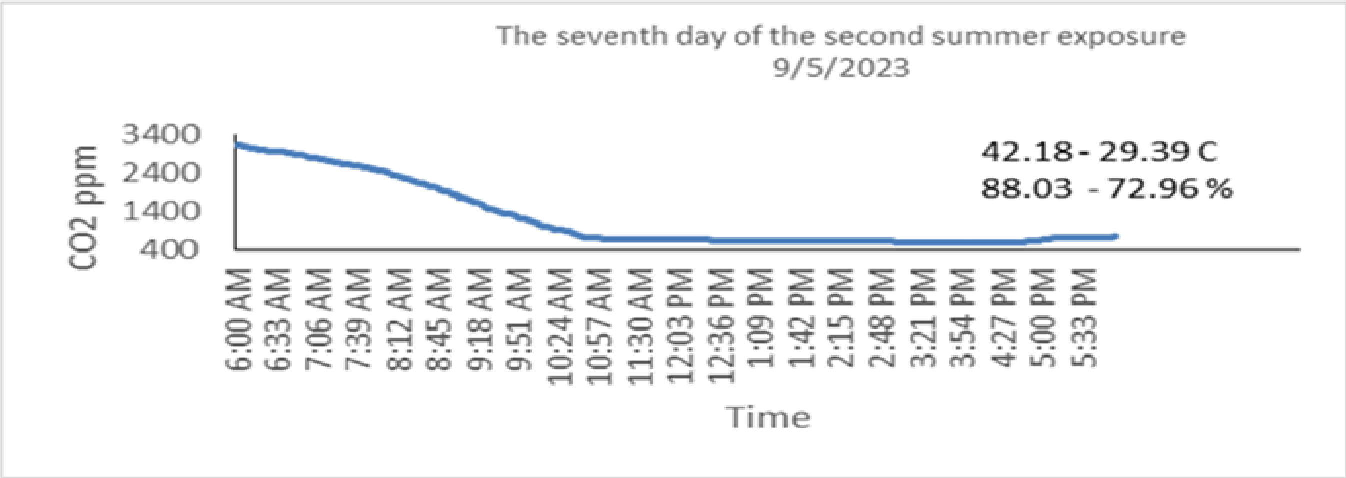


Figure 5. The first summer exposure of *H. tiliaceus* plants from (3-9)/5/2023

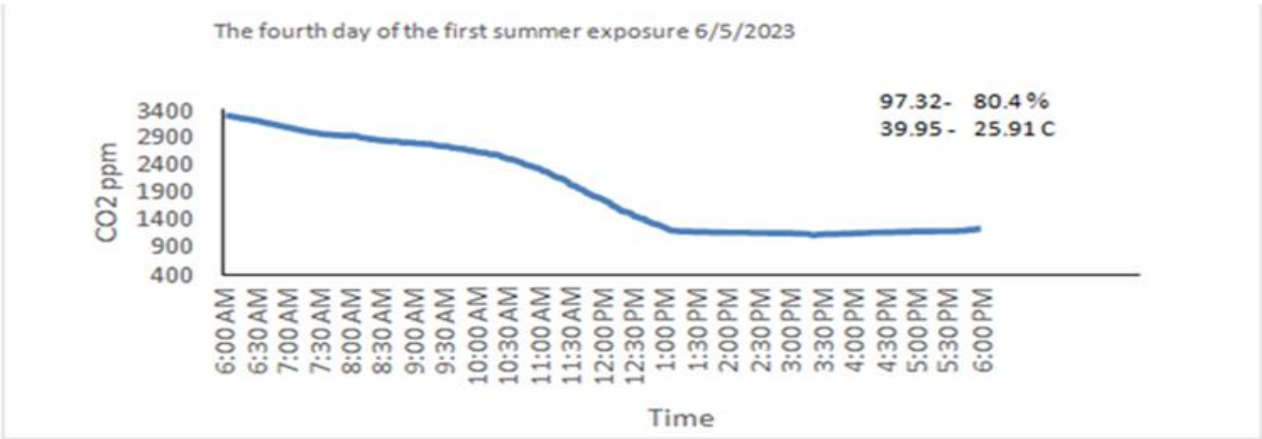


Figure 6. **The second summer exposure of *H. tiliaceus* plants from (17-23)/5/2023**

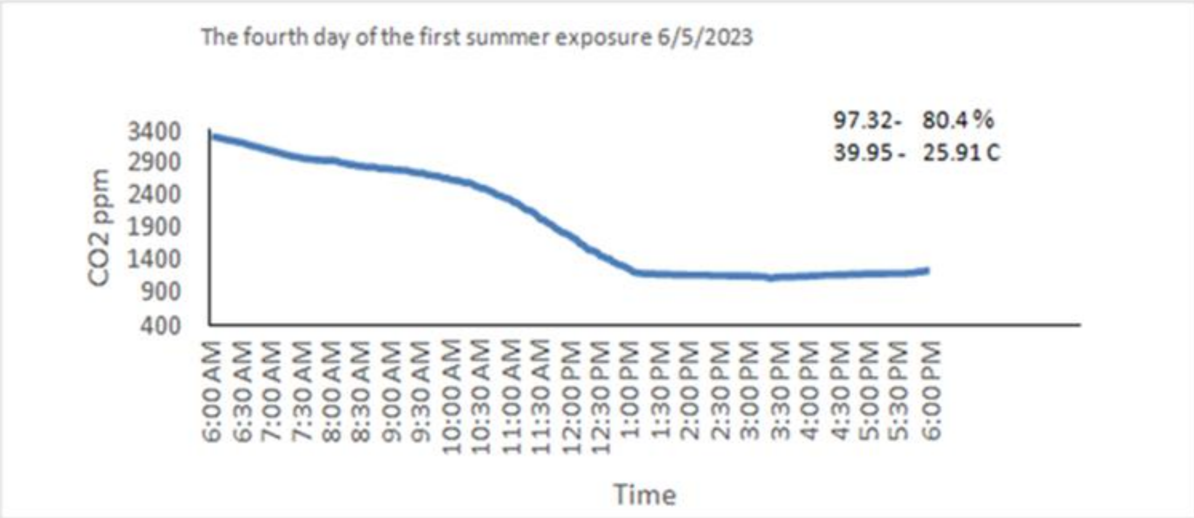


Figure 7. Summer exposure for the third week of *H. tiliaceus* plants from (1-7)/6/2023

Conclusion:

The findings highlight the importance of reducing air pollution and greenhouse gas emissions to mitigate the impacts, on plant pigments and ecosystem well-being. Protecting plant health and environmental quality can be achieved by cutting emissions through more effective energy, transportation and industrial methods. Considering factors like changes, environmental conditions and genetic influences upcoming research should delve deeper into understanding how plants physiologically respond to exposure, to CO_2. The effects of air pollution on plant ecosystems can be better understood and mitigated with the help of this comprehensive approach.

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