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The Climate of Buildings: The Pressure of Co2 in the Volume of the Street and the Role of the Palm Tree in its Regulation

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Abstarct

A global warming gas is a gas present in the atmosphere which will recover and absorb infrared radiation, the return of solar emissions, and which will have the consequence of warming the urban microclimate.

Long before the increase in temperature was observable; it was hypothesized that an increase in atmospheric CO2 could alter the urban microclimate. This hypothesis was based on a well-known physical phenomenon: the absorption of infrared radiation by certain gases, such as CO2. The palm can play a major role in the ecological balance due to its great characteristic of growing even in harsh climatic conditions and at high temperatures. In addition to this, the palm is one of the largest trees, so the property of capturing a large amount of carbon dioxide from the atmosphere is one of the most important features of the palm tree, which makes it the ingredients for solving the problems of global warming and climate change.

To know the real impact of palm on air temperature, experimental work was necessary, was carried out on the two streets located in Bab derb Turkish fort district in Biskra city (Algeria), which one of theme contain palms and the other does not contain palms and spread over a typical summer day with a measuring tool called "testo 480 –infrared sensor". We measured the air temperature on this device and changing only the sensors. In order to see the amount of CO2 variation in comparison to the climatic parameters at the same case study to caculate the pression of CO2.

Key words: building climate, experimental work, street contain palms, street does not contain palms, hot and dry climate, testo 480 – infrared sensor, amount of CO2.

INTRODUCTION

The urban environment is warming at a rapid pace. In question, the increase in greenhouse gases of human origin, with the consequences of health, ecological and humanitarian crises of which we see the beginnings. Despite this, the fight against climate change is a real opportunity for the transition to a low-carbon society on an urban scale. The measurement of carbon dioxide CO_2 is required in several applications, in our research the measurement of CO_2 is done using a measuring instrument called: carbon dioxide infrared sensor.

After the era of concrete that invaded cities by creating heat islands and damaging biodiversity, urban vegetation with palms is an advanced solution to regulate the urban microclimate. In adense urban fabric, the use of palms is envisaged. Palms have the advantage of filtering some of the solar radiation arriving on the street. The greening of the streets with palms allows to better regulate the heat and the insulation of the buildings.

ISSUES AND OBJECTIVES

Using strategies to access the design of a street commensurate with the climate, the environmental needs of the human being, and the achievement of thermal comfort within the streets. The building can be called a building climate balanced.

MATERIALS AND METHODS

The climatic conditions of the site are subject to the arid climate. The situations that interest us correspond to a hot day under typical summer conditions. Therefore, measurements will be made during the day: 5 and 6 July 2022 (two

days included in the overheated zone in the city of Biskra (Boukhabla M, Alkama d, 2010), bi-hourly measurements since 5 July 2022 at 8:00 am until 6 July 2022 at 8:00 am. This work focuses on the influence of palms on air warming. It proposes to contribute to the deepening of knowledge of the mechanisms of energy exchange by following a bi-hourly measurement approach, which is based on numerical modelling using a measuring instrument testo 480 (infrared sensor), *(Cf. fig.1),* to interpret the climatological parameters (air temperature, amont of CO2 to calculate the pression of CO2 for sunny and hot summer days. Field of study that we used is two streets located in Bab derb Turkish fort district in Biskra city (Algeria). *(Cf. fig.2),*

Figure 1. Measuring instrument, infrared sensor (testo 480). Source: Treatment, Authors, 2022

Figure 2. views of the investigation site and the two streets, located in Bab derb Turkish fort district in Biskra city, Algeria. Source: Field Survey, Authors, 2022

THE INVESTIGATIVE SITE – PALM TREE DESCRIPTION

The palm fronds are the leaves of the compound palm tree, which number between ten to twenty fronds, and the width of the frond increases when it meets the trunk, and each frond consists of several long, feathery leaves, numbering between one hundred and twenty to one hundred and forty leaves, which are yellow in color. And dark red to brown and these leaves are connected by the blade, and each leaf contains many thorns that are a mutated leaf, and each of them has a sheath surrounding the leg to protect it and prevent the leakage of fluids from it, (*Cf. fig.3),*

Figure 3. view of palm tree from streets located in Bab derb Turkish fort district in Biskra city, Source: Field Survey, Authors, 2022

The Parameters that Influence the Increase in Air Temperature in the Urban Environment

Carbon dioxide absorbs infrared (IR) radiation in a specific and unique way. This gas is detectable using IR infrared sensor techniques. (IR) sensors can withstand high levels of humidity, dust, dirt, and other demanding conditions. Conversely, other molecules, and in particular water vapor H_2O, carbon dioxide CO_2, absorb and emit infrared radiation. Water vapor is the third most abundant gas in the atmosphere and the first global warming gas.

THE EFFECT OF AIR TEMPERATURE AND STREET VOLUME ON THE MEASUREMENT OF CO2 PRESSURE

The ideal gas law can be used to calculate the pressure of gas CO_2 at given temperatures. In reality, gases do not behave exactly like ideal gases, but this approximation is most often used to describe the behavior of real gases.

The ideal gas law relates the state of a certain amount of gas to its pressure, volume and temperature according to the equation:

$PV = nRT \longrightarrow P = nRT/V$

Where :

p = pression [Pa]

V = volume of gas [m^3]

n = amount of gas [mol]

R = universal gas constant, (R= 8.3145 J/mol K)

T = temperature [K]

Calculation of V volume of gas in the street : V= Length* Lenght* Height

V= 80*7*4=2240m^3

1 ppm = 1 µmol /mol **(1** µmol =10^{-6} mol)

1ppm $\longrightarrow$ 10^{-6} mol/mol

CO_2 quantity (PPM) $\longrightarrow$ X

RESULTS AND DISCUSSION

Effect of Palm Tree on Co_2 Pression

By changing the air temperature and the amount of CO_2 we calculate the CO_2 pressure on the street : calculation example at 8h00 :

P=nRT/V

*P=600*10^{-6}**8.3145*307,25/2240

P= 684,275*10^{-6}(Pa)

Case 1: Street Does Not Contain Palms

In this case the measurement results of the air temperature, the amount of CO_2, in (ppm) and in (mol) are in Table 1 :

Table 1. Temperature of the air, quantity and pression of CO_2 in the street without palms.

Time (h)	Air Température (°C)	CO_2 quantity (ppm)	CO_2 quantity (mol)	CO2 Pression (Pa)
8	34,1	760	760*10^{-6}	866,74*10^{-6}
10	38,4	691	691*10^{-6}	799,08*10^{-6}
12	40,4	630	630*10^{-6}	733,22*10^{-6}
14	44,9	694	694*10^{-6}	819,30*10^{-6}
16	39,9	610	610*10^{-6}	708,81*10^{-6}
18	39	656	656*10^{-6}	760,07*10^{-6}
20	38,9	666	666*10^{-6}	771,41*10^{-6}

22	36	684	$684*10^{-6}$	$784,89*10^{-6}$
24	36,2	900	$900*10^{-6}$	$1033,429*10^{-6}$
2	35,8	820	$820*10^{-6}$	$940,351*10^{-6}$
4	31,6	760	$760*10^{-6}$	$859,69*10^{-6}$
6	33,1	720	$720*10^{-6}$	$818,45*10^{-6}$
8	32,4	705	$705*10^{-6}$	$799,57*10^{-6}$

Source : Field Survey, Authors, 2022

The normal level of CO_2 in the air is 350 to 450 ppm. CO_2 is an odorless, colorless and non-flammable gas. CO_2 has the particularity of absorbing certain infrared frequencies. Other parameters such as air temperature strongly influence CO_2 flows in urban areas.

The mineral surfaces in the street receives the CO_2. This gaz helps to increase the quantity of the CO_2 (mol) and to change the state of the liquid water into water vapour through the transpiration of the mineral surfaces. This mechanism allows it to guard against a too large increase in the temperature of the air. (*Cf. fig.4),* details the evolution of all these components during the day. Thus, at the solar midday, the air temperature reaches 45°C. (800 pas) of CO_2 this repeled gaz contributes to the phenomenon of the global warming while the remaining (700 mol) represents the quantity of the CO_2 exchanged with air for the whole the street that contributes to air warming. At night, however, the pression of CO_2 exchanges is reversed (1500 Pas) so that it is the urban heat island that gives heat to the street volume.

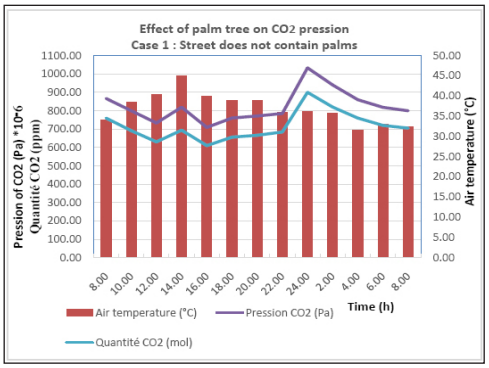

Figure 4. CO_2 pression and air temprerature transmitted in a street whithout palms.
Source : Treatment, authors, 2022

Case 2 : Street Contains Palms

In this case the measurement results of the air temperature, the amount of CO_2, in (ppm) and in (mol) are in Table 2 :

Table 2. Temperature of the air, quantity and pression of CO2 in the street contains palms.

Time (h)	Air Température (°C)	CO_2 Quantity (ppm)	CO_2 Quantity (mol)	CO_2 Pression (Pa)
8	30,7	487	$487*10^{-6}$	$549,25*10^{-6}$
10	32,9	487	$487*10^{-6}$	$553,27*10^{-6}$
12	35,5	345	$345*10^{-6}$	$395,25*10^{-6}$
14	38	320	$320*10^{-6}$	$369,57*10^{-6}$
16	34,9	346	$346*10^{-6}$	$395,62*10^{-6}$
18	30,3	511	$511*10^{-6}$	$575,56*10^{-6}$
20	29,6	420	$420*10^{-6}$	$471,97*10^{-6}$
22	28,7	398	$398*10^{-6}$	$445,92*10^{-6}$
24	28,3	580	$580*10^{-6}$	$648,98*10^{-6}$
2	27	520	$520*10^{-6}$	$579,33*10^{-6}$
4	27,9	435	$435*10^{-6}$	$486,08*10^{-6}$
6	30,7	518	$518*10^{-6}$	$584,22*10^{-6}$
8	32	337	$337*10^{-6}$	$381,70*10^{-6}$

Source : Field Survey, Authors, 2022

The storage capacity of a tree depends on a large number of factors, such as the species, the climate, the level of atmospheric CO_2 and the general ecosystem.

specific respiration rate can be reduced by both short-term exposure to increased CO_2 and long-term growth under high CO_2 (Amthor, 1995). However, the long-term effect may be similar when respiration rates are calculated per unit of nitrogen. With an increase in CO_2 the stomata conductance of most species will decrease, which may reduce transpiration per unit leaf area. The date palm can play a major role in the ecological balance due to its great characteristic of growing even in harsh climatic conditions and in high temperature soils. In addition to this, the palm is one of the largest trees, so the property of capturing a large amount of carbon dioxide from the atmosphere is one of the most important features of the palm tree, which makes it the ingredients for solving the problems of global warming and climate change. (*Cf. fig.5),*

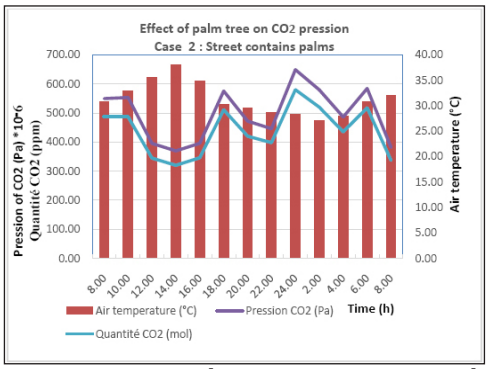

Figure 5. CO_2 pression and air temprerature transmitted in a street contains palms. Source : Treatment, authors, 2022

It has been shown that the water status of plants generally improves at high CO_2 content. Part of this effect can be attributed to reduced transpiration demand (per unit leaf area), and hence partial relief of water stress (Peyron G, 2000).

As for photosynthesis, which is the process that the plant generally needs to form glucose (sugar), the palm absorbs carbon dioxide, and in the presence of sunlight, it can generate sugar, oxygen and water, as in the following chemical equation :

$$CO_{2(g)} + 12\ H_2O_{(l)} + \text{photons} \longrightarrow C_6H_{12}O_{6(aq)} + 6\ O_{2(g)} + 6\ H_2O_{(l)}\ 6$$

Based on this equation,

264 tons of carbon dioxide and 216 tons of water can produce 180 tons of sugar and 96 tons of oxygen gas in addition to producing 108 tons of water.

This means that only 106 tons of water were used, and in the presence of light, chlorophyll can convert carbon dioxide into water and sugar.

The amount of carbon dioxide captured from the atmosphere depends on the size and area of the green parts of the plant. Since the palm is characterized by the large size and density of its fronds (the length of the frond is between 3 to 5 meters, and each frond contains about 150 leaves, the length of the leaf is about 30 centimeters and its width is about two centimeters) and its height (the approximate height is about 15 to 25 meters (*Cf. fig.6),* the volume of its capture of gas is large.

Figure 6. Palm frond shape and its leaves. Source: Field Survey, Authors, 2022

On the other hand, carbon constitutes 50% of the composition of dry wood, while water constitutes about 75% of the body of the living plant. As for the palm tree, the percentage of water is about 25% or less, and the percentage of carbon in steel is about 60%. This means that when wood is formed, it stores this percentage of carbon, which the plant has captured mainly from the atmosphere. And the amount of carbon that the plant takes in depends on the size of the plant and its age, and the storage will not be limited to the stem only, but the roots do this as well. Burning one ton of carbon generates 3.66 tons of carbon dioxide :

$$C+O_2 = CO_2$$

Or it can be said that the formation of one ton of carbon needs about 3.66 tons of carbon dioxide. And since the palm is one of the largest trees in size and one of the largest with roots, the density of the palm wood is between 200-900 kg per cubic meter, and its life may reach 100 years, so the palm when it is formed captures a large amount of carbon dioxide gas from the atmosphere and part of the carbon that It is extracted and stored in the stem and roots.

-If we assume a palm tree is 15 meters long and 0.5 meters in diameter :

-The mass of wood is about 1472 kg,

-Water constitutes: 1472 x 25% = 368 kg of it,

-While the rest is solid 1472 - 368 = 1103.8 kg,

-And accordingly Carbon: 81103. x 50% = 552 kg.

Thus, the palm during its growth period will have absorbed about: 366% x 552 = 2020.3 kg of carbon dioxide.

The Effect of the Palm Tree on the Measurement of Co_2 Pressure

The CO_2 content of the atmosphere is subject to temporal and spatial variations. A variation of the order of ±50 ppm/day is observed. In the morning, photosynthesis begins and a decrease in the CO_2 content is observed (300 mol) at 14h00. In the afternoon, the daily minimum is observed. At night, the CO_2 level returns to its maximum (590 mol) at 2h00 pm and this is according to the results of our research.

Water vapor is released through small valve-like openings called stomata, which regulate the passage of water vapor from leaf tissue to the surrounding air. The degree of opening of these pores depends on several factors such as the ambient concentration of CO_2.

Plant leaves lose water mainly by evaporation through the stomata. Stomatal density depends on plant species and can be related to their ecotype, between 300 and 800 stomata/mm^2 (Rowland-Bamford et al., 1990; Woodward, 1987, 1993; Kimball et al., 1986).

Palm trees are our best weapon in the fight against climate change, thanks to their ability to store CO_2. The normal level of CO_2 in the air is 350 to 450 ppm (parts per million air molecules). Experimentally, an increase in CO_2 of about 310 mol reduces the stomatal density but sometimes no effect is found beyond this level (Woodward and Bazzaz, 1988). Trees act as a carbon sink. They remove carbon dioxide from the atmosphere through photosynthesis.

Carbon-Eating Palms

Palm trees are an ally against global warming, because they absorb part of the carbon dioxide from the air,

As long as the world continues to burn fossil fuels, CO_2 concentrations will continue to rise. The fertilizing effect of CO_2 on plants will increase and climate changes may take place due to the combined increase of all greenhouse gases. Global agriculture will adapt to gradual regional changes, but sudden changes are likely to be more severe. Adaptation and mitigation actions could include the following:

- Selecting palms that can better absorb carbon dioxide when growing at high CO_2 content.

- The use of palm trees adapted to higher day and night temperatures and incorporating them into urban planning to improve the urban microclimate and combat air warming.

CONCLUSION

The increase in air temperature with the concentration of CO_2 pressure is therefore not only a statistical correlation. This is a physical hypothesis which, for the moment, is confirmed by observations.

To counteract global warming, it is necessary to know what the palm gives us, Temperature increases in a world enriched in CO_2 would increase the overall biomass productivity of vegetative crops.

Measuring CO_2 pressure is new to most of us. However, CO_2 has always been present in the air we breathe and more particularly in the air we exhale. The various studies and research on the impact of CO_2 pressure have led to an obvious conclusion. The conclusion clearly indicates that air quality and in particular CO_2 has an impact on humans, first linked to comfort and then to safety. Normal CO_2 pressure in air is 350-450 ppm. CO_2 is an odorless, colorless and non-flammable gas. CO_2 has the particularity of absorbing certain infrared frequencies. CO_2 measurement is becoming increasingly important for our comfort and safety.

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