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Technology as a support for the environment: monitoring air quality in a public building

Reflecting upon noise reduction, temperature control appears as a way to give comfort to all people who enter the jury court. As a result, the air quality was compromised due to the cumulative effect of the concentration of carbon dioxide and other gases that are harmful to health, due to the large number of people, through breathing. With the lack of air conditioning equipment with the function of air renewal, the environment becomes even more dangerous, causing excessive yawning, malaise and even suffocation. The present study aimed to monitor CO2 concentrations, ambient temperature and relative air humidity inside a room in a public building, which uses artificial air conditioning. The collections were carried out in February 2022 from 9:00 am to 3:30 pm, in the morning and afternoon, using portable equipment. Values recommended by ANVISA Resolution No. 9 were used as a comparison parameter. The results gave rise to knowledge about the air quality in this environment, with CO2 concentrations ranging from 957 ppm at 9:27 am to 1157 ppm at 12:46 pm, being above the reference rate of 1000 ppm, the temperature (°C) between 25.19 and 27.00, within the standards and humidity (RH) between 59.83 and 69.13, above the reference rate. It is therefore advisable to implement simple measures such as opening doors and windows during the intervals between trials to renew the air, in order to ensure comfort, well-being for the occupants and the reduction of CO2 concentration, the great villain of the greenhouse effect.

Keywords: Carbon dioxide; Artificial climatization; Air quality.

A tecnologia como apoio ao meio ambiente: monitoramento da qualidade do ar em edifício público

Pensando na redução dos ruídos, o controle da temperatura aparece como forma de dar um conforto a todas as pessoas que adentram o tribunal do júri. Com isso, a qualidade do ar ficou comprometida devido ao efeito cumulativo da concentração de dióxido de carbono e de outros gases que são nocivos à saúde, devido ao grande número de pessoas, através da respiração. Com a falta de equipamentos condicionadores de ar com a função de renovação de ar, o ambiente torna-se ainda mais perigoso, causando desde o excesso de bocejo, mal-estar e até asfixia. O presente estudo teve por objetivo monitorar as concentrações de CO2, a temperatura ambiente e a umidade relativa do ar no interior da sala da IV Vara do Tribunal do Júri da Capital –PE, que faz uso de climatização artificial. As coletas foram realizadas em fevereiro de 2022 das 9h00 às 15h30min, nos períodos da manhã e tarde, através de equipamento portátil. Utilizou-se como parâmetro de comparação valores recomendados pela Resolução nº 9 da ANVISA. Os resultados ensejaram o conhecimento quanto a qualidade do ar nesse ambiente, com concentração de CO2 que variam entre 957 ppm às 09h27min a 1157ppm às 12h46min, estando acima da taxa de referência de 1000 ppm, a temperatura (°C) entre 25,19 e 27,00, dentro dos padrões e a umidade (RH) entre 59,83 e 69,13, acima da taxa de referência. Aconselha-se, portanto, a implementação de medidas simples como a abertura de portas e janelas nos intervalos dos julgamentos para a renovação do ar, de modo a assegurar conforto, bem-estar aos ocupantes e a redução da concentração de CO2, grande vilão do efeito-estufa.

Palavras-chave: Dióxido de carbono; Climatização artificial; Qualidade do ar.

Topic: **Desenvolvimento, Sustentabilidade e Meio Ambiente**

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INTRODUCTION

In a brief analysis, atmospheric air is mostly composed of nitrogen (N), oxygen (O) and to a lesser extent, noble gases such as argon (Ar), krypton, helium, etc., and where, unfortunately, greenhouse gases are also present, such as: water vapor, methane (CH_4), carbon dioxide (CO_2), ozone (O_3) and nitrous oxide (N_2O), microorganisms and other particles, resulting from technological advances, population growth, growing number of industries, fires, deforestation, fossil energy, etc. Therefore, the air we breathe is increasingly polluted, putting life on Earth at risk. It can be even worse indoors, depending on the circumstances.

Regarding CO_2 pollution levels, according to the Global Monitoring Laboratory, in a measurement carried out in 2020 by the Mauna Loa observatory, in Hawaii (USA), it was shown that carbon dioxide concentrations (CO_2) in the terrestrial atmosphere reached 416.08 ppm, which is high and worrying, as it is the highest concentration of carbon dioxide in this station since the beginning of measurements, in 1958.

In 2017, CO_2 accounted for approximately 81.6% of all US greenhouse gas emissions from human activities according to studies by the Environmental Protection Agency (EPA, 2019). In the face of this concerning scenario, discussions on greenhouse gas emissions have been intensified to such an extent that in 2021 it was one of the central themes of COP26 (26th Conference of the Parties to the United Nations Federation Convention on Climate Change - UNFCCC, in Glasgow, Scotland.

The air quality in different parts of the world reflects society's disregard for collective health, the lack of care for the environment, the capitalist greed for profit above all, disregarding the principles of sustainability and, also, the lack of seriousness when it comes to public institutions in the fight against pollution, which results in an exacerbated increase in the emission of greenhouse gases and other pollutants (LISBOA, 2019).

Regarding the aspects of concentration of pollutants in indoor environments, it can be said that the rooms reserved for the Jury Court, for example, are typical places where there is a large concentration of people for a long period of time and without proper air renovation, which favors the concentration of several pollutants, mainly carbon dioxide (CO_2), released by breathing. Therefore, they demand periodic monitoring and careful analysis of the indoor air quality (PEREIRA et al., 2022).

The Jury is an organ of the Judiciary of the first instance, originating from the common justice. It is made up of a judge, seven people from the Sentencing Council, a prosecutor, the lawyer (of the accused), the witnesses (defense and prosecution), the defendant, the general public (family and friends of the defendant and the victim), journalists and law students (CAMPOS, 2015). Therefore, in order to have adequate thermal comfort in this environment, the use of air conditioners is essential. However, it is known that in environments with artificial air conditioning systems there are several chemical (toxic, carcinogenic, radioactive substances) and biological (pathogenic microorganisms) components of different origins, and that, in accordance with the physical conditions, such as humidity of the air, temperature and natural ventilation of the environment, these polluting elements can interact with each other (MOURA et al., 2019).

Data from the World Health Organization (WHO, 2018) confirms that about seven million people die annually due to pollution in outdoor and indoor environments. Therefore, in 2019, air pollution came to be considered by the WHO as the greatest environmental risk to health (OPAS, 2018).

Thus, the National Health Surveillance Agency (ANVISA), concerned with the health of the population, established parameters so that all artificially conditioned environments, in public and collective environments, are obliged to prepare and maintain a maintenance, operation and control plan (PMOC) of air conditioning systems. It is worth remembering that the air conditioning system is a determining factor for maintaining air quality in closed environments (BRASIL, 2003). In the State of Pernambuco, the agency responsible for assessing and monitoring air quality is the State Environmental Agency. The implementation of an air quality monitoring station at the Suape Industrial and Port Complex is part of the CPRH monitoring program. With the ability to read, process, store and transmit online data on the concentration of atmospheric pollutants to the CPRH, the system allows the CPRH to intervene as quickly as possible in the area, if air quality standards exceed the limits established in the current legislation. Inaugurated in December 2013, the Station issues reports in real time to the data receiving center, located at the State Environment Agency (CPRH). This is the first step towards building a network that will cover the entire state of Pernambuco and guarantee a better quality of life for the population (PERNAMBUCO, 2022).

THEORETICAL REVIEW

Air pollution

Initially, it is opportune to analyze the composition of atmospheric air in its unpolluted version, for a better understanding of the present reality of pollution high levels that affect not only the internal environments, but also the entire terrestrial atmosphere, identified by means of technologies, among those responsible for the greenhouse effect, such as carbon dioxide (CO_2), particles and microorganisms (TEIXEIRA et al., 2019).

The components of terrestrial atmospheric air, if it were not for the presence of polluting agents, would be: nitrogen (N_2) in a proportion of 78%, 21% of oxygen (O_2), approximately 1% of carbon dioxide, and noble gases (0.03 %) as helium, argon, krypton, neon, xenon and radon, as represented in figure 1.

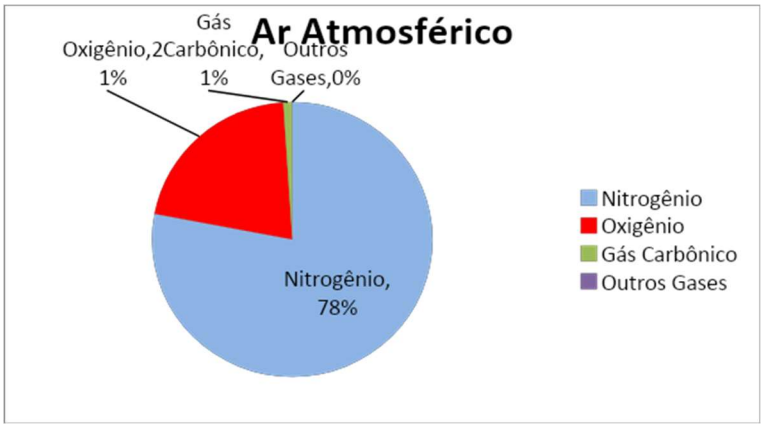

Figure 1: Atmospheric air composition.

However, it is known that the atmosphere does not consist only of gases, because there is dispersed solid material, such as pollen, microorganisms, dust, among others, as well as the presence of droplets from the condensation of water vapor, formed by rain, clouds and fog, albeit in a smaller amount (BAIRD et al., 2011).

Emphasizing the biophysical and chemical aspects, it can be said that atmospheric air has the basic utility of maintaining the life of living beings. However, for this to become a reality, its biological aspect must be adequate to the quality standard. According to Silva (2017): “This layer of air that surrounds the earth, in addition to being the raw material for the breathing of living beings (animals and plants), filters the sun's rays, cools the heat, balances the ecosystems”.

Living beings depend on atmospheric air for their survival (with rare exceptions that are anaerobic organisms), so if their purity is seriously compromised, their ecological function will perish. Referring to this aspect, Silva (2017) states that: “atmospheric air is of mandatory continuous consumption for living beings and is freely available in nature without any effort or burden for its use". This use is aerobic respiration, through the exchange of gases performed by visual beings in order to guarantee their existence, as well as maintain the atmospheric chemical balance (VASQUES, 2009).

According to medical doctrine, air suitable for breathing must always conform to certain qualitative and quantitative characteristics for respiratory function, as follows: Qualitatively, the air must contain oxygen and nitrogen (nitrogen - neutral breathing gas), with other gases, water vapor and various materials in suspension, however, oxygen is essential for the maintenance of life. Also, the ideal that does not contain unbreathable or toxic gases, or other substances that make it unfit to be breathed; the air must contain oxygen in a proportion of around 21%, with no substances and gases other than nitrogen present in considerable proportion (CARVALHO et al., 2008).

As can be seen, the quality of atmospheric air is an increasing concern of humanity, which is terrified and helpless to witness its deterioration through its own actions. This concern is not recent because, in a brief historical review, it can be seen that humanity has always maintained a growing rupture between itself and its surroundings. This process accelerates when, practically at the same time, the human being discovers himself as an individual and begins the mechanization of the planet, arming himself with new instruments in order to dominate it (LIMA et al., 2012). About the deterioration of the air, we can say that:

> The deterioration of the air started from the moment that the human being discovered fire in the Paleolithic Era, albeit unconsciously. In Rome, approximately 2,000 years ago, the first complaints about air quality began. At the end of the 13th century, the first air quality laws were signed in England. Since the Industrial Revolution, air pollution has taken on worrying proportions, becoming a public health problem, when techniques based on the burning of large amounts of coal, firewood, and later fuel oil, all highly polluting, began to be adopted. (CAVALCANTI, 2015)

Atmospheric air pollution became, from the beginning of the 20th century, a serious problem in industrialized urban centers, with the increasing presence of automobiles, which came to be added to industries as sources of pollution. Nevertheless, the issue of polluting cars is being resolved with the manufacture of electric vehicles, slowly but progressively (BRAGA et al., 2017).

Currently, the levels of pollutants, whether particles, dust, pollens, microorganisms, etc., that are released into the Earth's atmosphere are extremely worrying. Greenhouse gases have already exceeded the limits of tolerance, and have caused an increase in terrestrial temperature, resulting in an increase in the level of the oceans, instability of rains, drought, floods, various diseases, etc. (DIAS, 2004).

According to the figure above, it can be seen that between 1970 and 2010, the volume of carbon dioxide (carbon dioxide) present in the atmosphere more than doubled. In the last 11 years, this volume must have increased even more, considering the growth in the number of industries and automobiles, among others, powered by fossil fuels for the most part. On CO_2, then, it is opportune to emphasize once again that the emission of carbon dioxide (CO_2) results from the burning of fossil fuels and the manufacture of cement, among others, and is produced during the consumption of liquid, solid and gaseous fuels, and gas flaring (CARVALHO et al., 2013).

As can be seen, greenhouse gases are the great concern of humanity, which sees its health and its very existence in increasing threat. In short, all life forms are at risk of extinction. Therefore, it is necessary to make every effort to rule out this possibility. The main villain for atmospheric air quality, for external and internal environments, is carbon dioxide, which will be analyzed in its main aspects.

Carbon dioxide and other greenhouse effect gases

Carbon Dioxide is the main greenhouse gas among others capable of preventing infrared radiation from escaping our atmosphere, thus generating above-normal heating. The CO_2 in the atmosphere corresponds to 60% of the total of greenhouse gases, being, therefore, the villain of the atmospheric air, the aggravation of the greenhouse effect, the rise in global temperature, the threat to life on Earth. Other important greenhouse gases (GHGs) are: methane (15%); CFCs (24% - chlorofluorocarbons), and nitrous oxide (6%) (WHO, 2016), as can be seen in Figure 2.

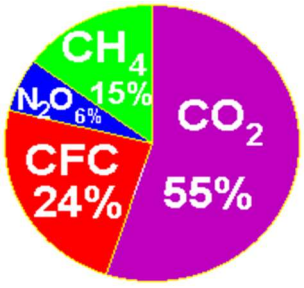

Figure 2: Influence of each gas in the aggravation of the greenhouse effect.

In addition to presenting a higher percentage among other greenhouse gases (GHG), the concentration of CO_2 has increased significantly in recent decades. It is worth noting, for comparative purposes, that the methane molecule, for example, absorbs infrared rays 23 times more efficiently than a CO_2 molecule. However, a molecule of CFC-12 (chlorofluorocarbon), a gas once widely used in refrigerators, but whose use is decreasing thanks to interventions by environmental agencies, has a heating power per molecule, 8,100 times greater than carbon dioxide (D' AMATO et al., 2010).

CO_2 is concentrated in the layer closest to the earth's crust – the Troposphere, where the air used for

breathing by plants and animals is found. It is basically composed of the same elements found throughout the atmosphere, Nitrogen, Oxygen and Carbon Dioxide (D'AMÉLIO, 2006).

Regarding nitrous oxide, its origin comes from natural processes resulting from biological activities in the soil and oceans, however, soil manipulation by humans, mainly due to the use of fertilizers, has increased the emission of this gas into the atmosphere. In this case, urgent intervention by the responsible bodies is necessary in order to reduce the use of these products (D'AMÉLIO, 2006).

Ozone (O_3), a gas naturally present in the atmosphere, between 10 and 16 km from the Earth's surface, in a percentage of about 10%, in addition to being a very harmful gas for human health, also has a high heating power. The remaining 90% of this gas is found in the Stratosphere (at a distance between 17 and 50 km), called the “ozone layer” (ROCHA, 2003), as shown in Figure 4.

The ozone layer (ozone present in the stratosphere) absorbs part of the sun's ultraviolet radiation that is harmful to life. Hence, it is an important gas in these conditions.

If CO_2 emissions continue to increase at the same rate recorded in recent decades, the Earth's temperature could increase to the point of causing major disasters, with immeasurable consequences for living beings. For example, ice in the polar regions could melt even more, at greater speeds, causing floods on large stretches of the coasts of continents, and even destroying coastal cities. Ocean currents could also change in ways that alter the distribution of heat on Earth, large agricultural regions could become deserts, and violent storms could arise more frequently as a result of climate variations. People's health will be at serious risk, in short, all living beings, animals and plants will be affected (ROCHA, 2003).

The main effects of these climate changes can be analyzed from global warming. This process results from changes in natural dynamics produced and intensified from the emission of gases into the atmosphere (MENDONÇA, 2006). According to Pedrini et al. (2016): “consequences such as: increase in temperature and ocean levels, loss of biodiversity of several marine and terrestrial species are, in fact, observed today”.

However, Conti (2005) emphasizes that the natural and anthropic causes relevant to this process must be analyzed and not just attributing climate change to the rise in global temperature and its consequences, since climate changes are also related to to planetary dynamism influenced by several factors in the local and global sphere.

Complementing the claims about the greenhouse effect, we can say that:

> Regarding the natural greenhouse effect, anthropic activity has modified natural environmental processes, causing the absorption of ultraviolet rays (UV) by the ozone layer (O3), continuously increasing atmospheric concentrations of gases such as: carbon dioxide (CO2), methane (CH4), nitrous oxide (N2O), chlorofluorocarbons (CFCs) and other greenhouse gases (GHGs), which can cause the Earth to overheat. (SILVA et al., 2009)

Another important aspect that has significantly contributed to the rapid increase in the urban population is the rural exodus and urbanization. Cities grow at an accelerated rate, changing the way people and society live. On this, Almeida et al. (2019), state that: “since the 19th century, the accumulation of GHGs has been noticed, and in this period, society began to understand that these gases, especially CO_2, can bring harm to the planet, such as temperature increase and climate change”.

Carbon dioxide in internal environments: causes and effects

In closed environments, where there is practically no circulation of free air, the temperature often becomes unbearable. Thus, fans are used, or the use of air conditioners, an efficient technological resource to keep the room temperature under control, so that it becomes pleasant for everyone. However, the accumulation of carbon dioxide in these closed spaces tends to be high, harmful to health, when filled with people, due to the respiratory process.

Studies in several countries have been developed in recent decades on air quality in climate-controlled environments. In 1998, with the death of the then Minister of Communications Sérgio Motta, due to pulmonary infection, perhaps as a result of the lack of maintenance of the air conditioning system in his office, the Ministry of Health issued Ordinance No. 3523/1998, in order to determine Technical Regulations with basic measures to be adopted regarding the inspection, cleaning and maintenance procedures of air conditioning systems, to ensure air quality in internal environments, as well as preventing risks to the health of the occupants of these spaces (BRASIL, 1998).

The paragraph above, therefore, is an example of the risk that one runs when staying indoors without making sure that your air cooling system is properly inspected, clean and with its up-to-date maintenance and that there are exhaust fans. The risks are immeasurable for the health of those who occupy these closed environments for a long period, because, in addition to pathogenic microorganisms, various particles, the high concentration of CO_2 is a considerable danger factor for health.

Concerned with this dangerous situation in indoor, closed environments, regarding polluting agents, ANVISA edited Resolution 09 in 2003, as shown in Table 1.

It is timely to point out that the National Council for the Environment (CONAMA), in line with ANVISA guidelines, created the National Air Quality Control Program (PRONAR) in 1989. This program stands out for being one of the tools aimed at protecting the health, well-being and improving the quality of life of people living in society. It therefore aims, by complying with the rules designed to limit the levels of pollutant emissions, to improve the quality of breathing air. PRONAR is the mechanism adopted by the entire country to, in an integrated way with economic and social development, focusing on the principles of sustainability, seek air quality (BRASIL, 2015). Regarding the absence of air renewal in closed environments, we can say that:

> The lack of air renewal in closed indoor environments can be a factor in the production of bacteria and substances harmful to health, including the accumulation of carbon dioxide. Therefore, specific measures and standards must be adopted, especially when it comes to air conditioning, for use inside closed rooms, as otherwise there is a risk of problems beyond health. Therefore, the rules established by Organs responsible bodies must be complied with. It is worth noting that the main groups of air contaminants in an air-conditioned environment are microbial particles, including algae, fungi, bacteria and viruses, originating from the outside air, the air conditioning system, construction, furniture, carpet and, mainly, from their occupants, in addition to the accumulation of CO_2. (GONTIJO et al., 2010)

ANVISA, through RE nº 176/2000, defined reference standards for indoor air quality in artificially conditioned environments for Public and Collective Use, in compliance with Ordinance nº 3523/98 – MS. As a result of the knowledge and experience acquired in the first two years of validity of RE No. 176/00 - ANVISA

and with the objective of complementing the basic measures defined by Ordinance No. 3523/98 - MS, the National Health Surveillance Agency defined the two main sources of pollutants (biological and chemical) that can be found in air-conditioned closed environments (ANVISA, 2013), as seen in Table 3.

Internal environment air quality

Indoor air is defined as that of non-industrial areas such as offices, schools, hospitals and housing (WANG et al., 2019). Analyzing the air quality is essential as a way of ensuring health to the occupants of different buildings, as well as a better performance of their activities (GIODA et al., 2003).

Still, according to the authors mentioned above, the concern with Indoor Air Quality practically started with the propensity to build practically closed buildings, with little air circulation, for aesthetic reasons, acoustic insulation and also for the implementation of air conditioning technologies in these environments, as compensation, which ended up generating an increase in cases of problems related to air quality in these places (GIODA et al., 2003). This practice, now practically abolished, is an absurdity, incompatible with what is currently known about the importance of keeping environments ventilated and healthy.

Studies on indoor air quality began to be implemented, mainly after it was found that the rates of air exchange in these indoor environments were low, insufficient to maintain a healthy environment, and this was the reason for the increase in concentration of biological and non-biological pollutants in the air in these places, causing risks to people's health. This concern has its reasons due to the fact that most people (around 80-90%) spend most of their time in these internal spaces, consequently exposed to pollutants in these environments, whose health consequences are known to be disastrous (LEE et al., 2014).

According to the United States Environmental Protection Agency (EPA), the concentration of pollutants in closed, indoor spaces can be up to five times higher than what can be seen in open environments. Therefore, the exposure of people in these indoor environments becomes a health risk, requiring periodic monitoring to regulate the present air (ALA, 2010).

According to the parameters of the World Health Organization (WHO), the air is not of good quality in most closed places, such as cinemas, schools, homes, companies, and even hospitals, among others; this is mainly due to the lack of adequate and periodic cleaning of air conditioning equipment and the lack of control over possible sources of contamination (WHO, 1998). According to Carmo et al. (2009):

> Various pollutants such as carbon monoxide and dioxide, ammonia, sulfur oxide and nitrogen are produced inside the building by building materials, cleaning materials, mold, household activities (cooking, washing and drying clothes), among others. The occupants of buildings themselves contribute substantially to the pollution of indoor environments, both through breathing and perspiration, as well as through the transport of potentially disease-causing microorganisms. Not to mention the cigarette, one of the main villains of any environment.

In Brazil, the concern with indoor air quality became relevant when the Federal Government, in 1996, based on research carried out in international bodies, prohibited smoking in closed places, for collective use, based on studies carried out by international agencies. Therefore, it was concluded that tobacco smoke is

extremely harmful to health, contaminating indoor air quality (BRICKUS et al., 1999).

It is known that ventilation is essential for good indoor air quality, transforming it for the better. Ventilation is the main instrument for controlling indoor air quality. Thus, ventilation is understood as a set of events that allows not only the supply of external air, but also the removal of stale air. Basically, this process is summarized in: external air entrance, conditioning and exchange of polluted air throughout the environment (JONES, 2005). However, ventilation systems, when poorly used and without proper maintenance, become real sources of pollutants, in general, particulate materials and microorganisms, due to the accumulation of moisture in them.

Indoor air pollution is extremely harmful to the people who live in it to such an extent that the World Health Organization (WHO) recognizes the resulting symptoms and names them Sick Building Syndrome (SED), which are symptoms without a defined origin and without any possibility of finding a certain etiology, thus being considered unknown (WHO, 1984).

According to the World Health Organization (WHO, 2018), the criteria for considering a "sick building" are: a) irritated mucous membranes; b) neurotoxic effects; c) respiratory and skin problems and; d) changes in the senses, for at least two weeks, especially when these symptoms disappear when the affected person moves away from the building (CARMO et al., 2009). Also, according to the aforementioned authors:

> It is accepted that the main factors related to EDS are: aero dispersoids (dust, fibers); bioaerosols (fungi, bacteria, viruses); chemical contaminants such as VOCs (Volatile Organic Compounds) and formaldehyde; contaminants generated by human metabolism; inadequate ventilation, among others. (CARMO et al., 2009)

As can be seen, indoor air quality basically depends on the exchange of indoor air through permanent natural ventilation. Closed environments without monitoring and, consequently, without measures to maintain a healthy environment, becomes dangerous for the health of those exposed to them (BRASIL, 2013).

Undoubtedly, outdoor air can be the main source of pollutants (physical, chemical and biological) for the indoor environment. Mainly in locations where vehicle traffic is intense and also in industrial parks. The sources of these contaminants are numerous, such as: human activity (microorganisms, CO_2, etc.) and even masonry structures (radon), among others. Therefore, the main pollutants of indoor environments can be listed: non-biological contaminants, such as carbon monoxide and dioxide; nitrogen oxide and dioxide, sulfur dioxide, ozone, particulate matter, cigarette smoke, volatile organic compounds – fungi, bacteria, among others (CARMO et al., 2009).

The issue involving the pollution of indoor environments is so serious that the National Council for the Environment (CONAMA), on November 16, 2018, regulated Resolution No. 491, which updates the air quality theme and sets verification parameters. ANVISA also adjusted Resolution No. 176, of October 24, 2000, ANVISA Resolution No. 9 of 2003, which deals with standards related to Indoor Air Quality in artificially conditioned environments for public and collective use (SANTOS et al., 2017). All to ensure that the indoor air is as good as possible.

Monitoring and air quality

Thanks to technological advances, practically all areas of human activity, all scenarios where humans are present, are monitored, whether in city traffic, in residential, commercial, industrial, hospital, military buildings, etc., generally using cameras, on-site sensors, and even through specific satellites installed in geostationary orbit, about 100 to 200 km from Earth. These technologies are advancing and improving more and more in other areas, such as those related to the environment, open spaces and indoors, for the detection of polluting elements present in the air, be they of any type: chemical, biological, non-biological particulates, among others, which, in excess, can be extremely dangerous for people and even for other animals. It is on this aspect that this topic will focus, searching the relevant literature for scientific publications corresponding to these relevant environmental issues.

In order to define the level of air pollution, there are measurements based on the concentration of contaminating elements. These ratios are calculated in micrograms per cubic meter of air (µg/m3), or by the number of contaminant molecules per million air molecules (ppm) (NOBRE et al., 2010). In this regard, it is important and opportune to refer to CONAMA Resolution No. 3/990 on air quality standards, for a better understanding: (3/1990)

> **Art. 1 -** Air quality standards are the concentrations of atmospheric pollutants that, if exceeded, could affect the health, safety and well-being of the population, as well as cause damage to flora and fauna, materials and the environment. generally.
>
> **Sole paragraph:** An atmospheric pollutant is understood to be any form of matter or energy with intensity and in quantity, concentration, time or characteristics that do not comply with the established levels, and that make or may make the air: I - Improper, harmful or offensive to health; II – Inconvenient to the public welfare; III – Harmful to materials, fauna and flora; IV – Harmful to the safety, use and enjoyment of the property and to the normal activities of the community. In accordance with Law No. 6,938/81 of the National Environmental Policy, air quality standards were incorporated as one of the instruments of environmental policy, (Articles 2, VII, 4, III and 9, I). (BRASIL, 2018)

Hence the pressing need for air monitoring in an indoor environment. Regarding the internal environment, permanent monitoring with consequent measures can avoid high levels of pollution and, thus, rule out the possibility of health problems (SANTOS et al., 2017).

According to Sissinus et al. (2013), the environmental assessment is the exact indication of the concentration of contaminants in different environments: soil surface, deep soil, sediment, surface water, groundwater, air, biota - in addition to dust, emissions atmospheric, liquid effluents (industrial or domestic) and solid waste, and their comparison with values of natural levels and/or reference values (maximum permissible values calculated by regulatory instruments). Monitoring is configured as the extension of an evaluation; it can be performed manually, through the use of measuring instruments, or automated, through the use of sensing instruments that operate without the need for intervention.

Environmental assessment becomes environmental monitoring when it becomes periodic. It consists of actions of collection, storage, study and systematic evaluation of environmental samples, in order to identify native natural elements, contaminants and their respective concentrations (SISSINO et al., 2013).

Air quality monitoring is extremely important, as it measures the CO_2 concentrations, temperature

and humidity of the environment, allowing the generation of data on the current conditions of air quality, allowing the storage of data for future consultations and comparisons, as well as allows decision makers to plan the necessary actions and public policies to ensure good air quality (ASSAF et al., 2019). In Brazil, the National Air Pollution Control Program (PRONAR) created in 1989 by CONAMA was considered one of the basic tools of environmental management for the "protection of the health and well-being of all, with the purpose of corroborating with the economic and social development of the country in an environmentally safe way" (BRASIL, 1989).

Monitoring data made several epidemiological studies possible in the 1980s and 1990s, which revealed knowledge about the adverse effects on human health due to air pollutants - and which culminated in the Air Quality Guide by the World Organization for Health (WHO, 2016). The publication of this guide established the safety limits of exposure to toxic pollutants for people. Human exposure occurs when a person comes into contact with a toxic pollutant whose concentration exceeds the tolerance limits indicated by ambient air measurement. Therefore, the WHO recommends that countries establish an air quality monitoring network, whose purpose is to prevent harmful events for public health (WHO, 2016). And it is in this sense that PRONAR acts, in line with the WHO recommendations, defining rules and establishing limits on emission levels of pollutants from the most diverse sources, with the purpose of, according to BRASIL (1989), improvement in air quality, compliance with established standards and non-compromise of air quality in areas considered not degraded (BRASIL, 1989).

Currently, air pollution is considered as one of the main risk factors of mortality worldwide, as well as poor diet and smoking (BURNET et al., 2019). Although, as is known, the risk attributable to tobacco for illness is greater, exposure to air pollution occurs for billions of humans. According to Assaf et al. (2019):

> WHO (2016) studies indicate that more than 90% of the world population is exposed to the risks of outdoor air pollution, on a daily basis, resulting in about one death in 10 deaths (11.6% of all deaths globally), totaling five million annual deaths and, among them, 600 thousand children.

MATERIALS AND METHODS

As a methodology, a descriptive research was carried out through a quali-quantitative approach. Descriptive because the case study, analysis, recording and interpretation of data were carried out without the interference of the researcher.

As for the approach, this was quantitative because measurements of CO_2 concentration, temperature and humidity were carried out, through data which were collected and quantified from the sample and presented in the form of graphs. The qualitative character is given precisely by the analysis of the data collected, in order to propose suggestions for possible solutions to the problem in question.

A bibliographic research was also adopted, which according to Gil (2012) is based on material already prepared, such as books, magazines and articles. This type of research gives you the advantage of having a wider coverage of information than you could look at directly.

Study location

The study was developed in a public building room which won't be identified.

Study area characterization

In the room, approximately 120 people can be seated, in addition to two staircases that give access to the seats (right and left side) and that also serve to shelter people standing, when the judgment has great repercussions in society and in the social media. Its total area measures 235.50 square meters, with seven glass windows and two doors that give access to the plenary hall (left side), in addition to the third door (right side) that gives access to the balcony.

The room was chosen to carry out the monitoring of CO_2, temperature (°C) and humidity (RH), as it presents a large concentration of people for a long period of time, however, due to the Covid-19 pandemic, the number of people was very reduced, considering the restriction measures contained in DECREE No. 50.752, issued by the State Government on May 24, 2021, aiming to contain the transmission of the disease, in addition to the mandatory use of masks.

According to the technical standards of RE 09/2003 by ANVISA, for interior monitoring, when the built area is up to 1000 m², only one sampling point is necessary and it must be located at a height of 1.5 m from the floor, in the center of the environment or in an occupied area. Since the room where the study is located is 235.50 m², a monitoring point was fixed in the center of the room.

The collections were carried out between February 08 and 23, 2022. In addition to another monitoring with the plenary completely empty, carried out on May 11, 2022, in the morning shift (before the start of work).

On the days of the monitoring, an average of 40 people were present. There are two doors that give access to the plenary and through which all the people involved enter. These doors remained closed throughout the monitoring period. All windows were closed and nine air conditioners turned on by the end of the trial. Only one door (right side) that gives access to the balcony was open at all times.

Equipment

The carbon dioxide detector (Figure 3) detects carbon dioxide from the local environment through the principle of absorbing infrared light sources. The product has the features of temperature, humidity, trend graph, stores up to 999 groups of data log, 3.2 inch full color display, with alarm setting (when exceed setting value: 1000 PPM), data log of time interval measurement, real-time date and time display, rechargeable lithium battery, or charging. Separate external use. With professional grade detection technology and stable performance and high accuracy. Suitable for public places, agriculture, livestock, industry and others.

Figure 3: CO2 Detector.

Data analysis

Data were supplied in number of collections, date and time, in standard measurement units (ppm / oC / RH) by the equipment itself and transformed into a table. With the monitoring data, they were tabulated and converted into percentages using the Microsoft Office Excel program.

RESULTS AND DISCUSSION

It is possible to observe in Figures 4 and 5, the maximum and minimum concentrations of CO_2 as a function of the time, with the occupation of people in the jury court at the time of collection, perceiving its variables throughout the trial. It is important to note that the number of people was well below the maximum occupancy capacity of the room, and these values could be even higher under normal conditions.

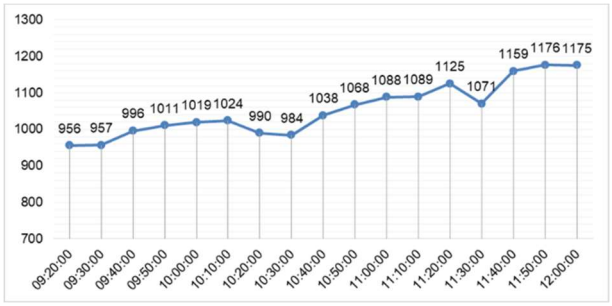

Figure 4: Average CO2 concentration at the IV Jury Court (Recife) – Morning.

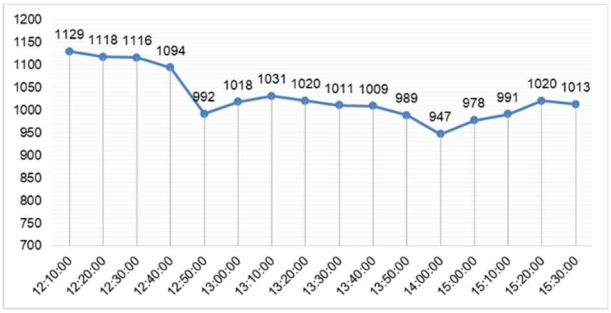

Figure 5: Average CO2 concentration at the IV Jury Court (Recife) – Afternoon.

When the work to start the trial begins, almost always around 09:50min (1011ppm), an increase in concentration was observed and it exceeded 1000ppm and remained. When some of the participants left at 10:29 am, there was a substantial drop in the concentration of CO_2 in the environment under study (990ppm), going back to exceed 1000ppm when other participants or servers entered.

In the afternoon shift (Figure 6), the CO_2 concentration exceeded 1000ppm right at the beginning, from 12:00 (1175ppm) and remained above the allowed until 12:40min (1094ppm). At the time of the lunch break, with the vacancy of part of the room, there was a drop, reaching 947ppm, around 14:00 hours.

The values obtained, at certain times, are in disagreement with the current norm, remembering that poor air quality can harm the health of the individual throughout their existence, among the main diseases are: pulmonary, cardiovascular diseases and cerebrovascular accidents, cancer and diabetes; the development of babies even before they are born; dementia in adults and cognitive development in children

(ASSAF et al., 2019).

Regarding the temperature measurement in the plenary where the study was carried out, in the morning the temperature indicated an average of 26.69 oC, at 9:20 am, with a high temperature at 10:40 am, reaching 27ºC, which is the highest temperature measured in the period. In the afternoon at 15:00, the temperature showed a drop of 23.91ºC, which was the lowest temperature measured (Figures 6 and 7).

Figure 6: Average temperature variation (°C) at the IV Jury Court (Recife) – Morning.

Figure 7: Average temperature variation (°C) at the IV Jury Court (Recife) - Afternoon.

The air conditioning in the room is made up of nine air conditioners and does not have an air renewal system.

Chart 7 shows the variation in air humidity in the morning, with a minimum of 59.88% at 10:10 am and a maximum of 66.0% at 11:30 am.

In the afternoon (Chart 9), we observed a minimum air humidity of 61.3% at 12:20 pm, and a maximum of 69.13%.

According to the World Health Organization (WHO), the ideal relative humidity for the individual's health must maintain rates below 60%, that is, the values collected during the research are classified as: a percentage slightly above the recommended for human health in the morning and afternoon (Figures 8 and 9).

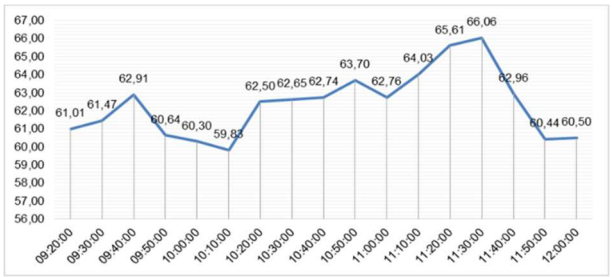

Figure 8: Average of air humidity (RH) at IV Jury Court (Recife) – Morning.

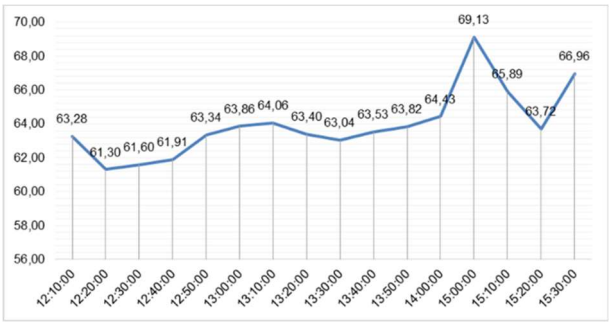

Figure 9: Average of air humidity (RH) at IV Jury Court (Recife) – Afternoon.

In a brief analysis of indoor, closed environments, these concentrations can be higher than those found outdoors, due to the respiratory process of people, and it becomes even more dangerous for being odorless and tasteless, thus, difficult to detect, being necessary to use specific instruments for measuring the air.

During the research, there was a need to carry out measurements at the study site without the

presence of people, with windows and doors open in order to analyze whether there would be a reduction in CO_2 concentrations. This measurement was performed first thing in the morning (Figure 10).

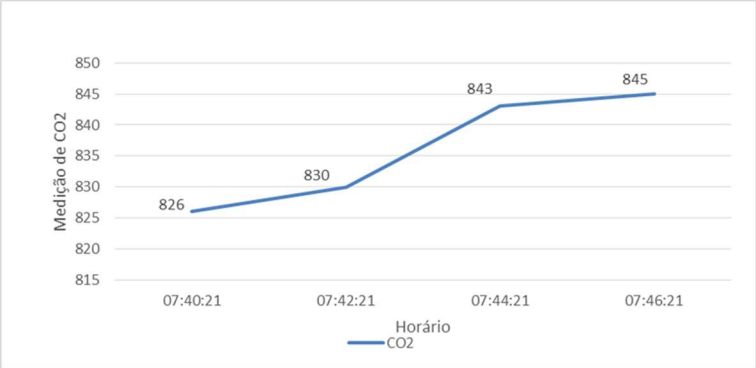

Figure 10: Measurement of CO_2 concentration without people present.

The result of the measurement of CO_2 concentration in this environment: At 07:40min., 07:42min., 07:44min. and 07h46min., the equipment indicated: 826ppm, 830ppm, 843ppm and 845ppm (Figure 19), respectively, however, these concentrations are considered high because the environment was unoccupied and receiving natural ventilation (outdoor air).

As for descriptive statistics, the results of CO_2 levels, temperature and humidity are represented in the following tables 1, 2 and 3.

Table 1: Descriptive Statistics Results - CO2.

CO_2	
Average	1.068,21
Standard error	5,9359
Median	1057
Mode	955
Standard deviation	105,0161172
Sample variance	11028,38488
Kurtosis	-0,873793468
Asymmetry	0,419982695
Interval	429
Minimum	918
Maximum	1347
Sum	334350
Counting	313

Table 2: Descriptive Statistics Results – Temperature.

Temp	
Average	25,72
Standard error	0,05
Median	25,75
Mode	25,75
Standard deviation	0,94976133
Sample variance	0,902046584
Kurtosis	2,422939031
Asymmetry	0,577527204
Interval	6,78
Minimum	23,34
Maximum	30,12
Sum	8051,46
Counting	313

Table 3: Descriptive Statistics Results – Humidity (RH).

RH	
Average	62,9523
Standard error	0,18736
Median	62,71
Mode	66,06
Standard deviation	3,31479
Sample variance	10,9878
Kurtosis	0,19376
Asymmetry	0,0261
Interval	18,47
Minimum	52,76
Maximum	71,23
Sum	19704,1
Counting	313

CONCLUSIONS

The results of this study regarding the concentration of CO_2 determine that even with the low number of people in the room due to the pandemic, at various times the values surpassed the maximum reference concentration (1000ppm) established by ANVISA.

It is possible to conclude that the increase in the concentration of this gas was due to the metabolism of the people who participate directly in the trial, in addition to: visitors, servers, police, among others, suggesting that there is poor air quality and that it is necessary to replace the air conditioning system because the existing one does not have an air renewal system and/or the opening of doors and windows in the intervals of the trials for air renewal. To prevent the negative impacts to the health of those present and the environment concerning excess carbon dioxide in air-conditioned environments, it is essential that the environment has good ventilation/exhaustion of indoor air.

In the present study, the values indicated referring to the relative humidity of the air are in a percentage above that recommended by the WHO for human health. As for temperature, from the values collected there was no thermal discomfort in the participants present during the research.

It is necessary to take simple actions such as opening doors and windows during the intervals between trials to renew the stale air, in order to provide well-being to occupants and to mitigate Carbon Dioxide (CO_2) emissions and the elaboration of a complementary study in other public buildings where there are already air conditioning systems with air renewal for a comparison of concentration values of this gas so harmful to the environment.

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