Journal of Current Medical Research and Opinion
Received 15-05-2024 | Revised 16-05-2024 | Accepted 15-06-2024 | Published Online 17-06-2024

DOI: https://doi.org/10.52845/CMRO/2024/7-6-21 ISSN (O) 2589-8779 | (P) 2589-8760

CMRO 07 (06), 2843-2857 (2024)

Original Research

An Evaluation of the Air Quality Index in Najaf Governorate (Al-Sadr Teaching Hospital for the Case Study

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Abstract:

Monitoring indoor air pollution in health institutions is important for building occupants. In this study, an environmental assessment of the indoor air quality index (AQI) was conducted at Al-Sadr Teaching Hospital, where volatile organic compounds (TVOC), carbon monoxide (CO) concentration, and carbon monoxide (CO) concentration were measured. Carbon dioxide (CO2) and formaldehyde gas concentration (HCHO), using an Air Quality Detector.

In this study, 59 sites were measured within Al-Sadr Teaching Hospital, and the results showed that 25 sites out of 59 were the most polluted sites, which had an air quality index category ranging from (6-5), that is, within the range of severe to dangerous pollution, as these places are closed and do not contain a ventilation system. It is suitable and contains electronic devices inside it, some of which deal with microorganisms, in addition to the use of sterilizers and scented detergents, which expose patients and even medical staff to severe and toxic health effects the longer they stay and are exposed to these gases, as the gases exceed safety limits. The results also showed the places Which recorded moderate pollution values, which were 5 sites out of 59, and the air quality index value was (4). While the least polluted places, which numbered 21 sites out of 59, were recorded as the air quality index value ranged from (2-1), so the air quality index category was excellent to good because the places had appropriate ventilation systems and were not crowded with people at that time.

Keywords: Air Quality, Najaf Governorate, Al-Sadr Teaching Hospital, Case Study

Introduction:

The issue of air pollution is one of the issues that worries people, especially since air is considered as necessary for humans as water is, and it is even more important and necessary.

We often spend long hours indoors, and the air we breathe is not always of high quality. The presence of people inside does not necessarily mean that they are breathing fresh air. The air inside may be exposed to many factors that in turn affect the health of everyone in the building, from children and adults to people with chronic and long-term diseases. People who stay inside for long periods are usually more affected by Air pollutants, as these pollutants can increase disease symptoms in people with lung cancer or asthma and many diseases that are dangerous to the health of healthy or injured people.

If the building or institution is not sufficiently ventilated, a group of pollutants will accumulate. This pollution results in several health effects, including allergies, respiratory tract infections, headaches, and poisoning. There are many factors that contribute to the decline in air quality in closed spaces, such as asbestos. (which can be found in building materials such as paints and coatings) as well as dust and chemicals emitted from uncontrolled scented materials, as well as biological pollutants such as moisture, mold, viruses and bacteria, in addition to radon gas, formaldehyde gas and carbon dioxide.

Research Aims:

The study aims to measure and evaluate the air quality index in Al-Sadr Teaching Hospital. It also aims to indicate the most important sources of air pollution in the internal environment of the hospital departments, and to detect the concentrations of some gaseous air pollutants (TVOC, CO, CO2, HCHO).

IR Pollution:

Air is known as a group of gases in different proportions that include the atmosphere of the planet Earth. Therefore, air is one of the most important elements that make up the environment. Although it is the most abundant element, it is considered the most important, as it represents the main support of life for various living organisms.

The air basically contains nitrogen gas, oxygen, argon, hydrogen, and carbon dioxide in different proportions. Some of these elements are present in the air in fixed concentrations, such as nitrogen gas (78.0842), oxygen (20.9476), and hydrogen (0.0005), regardless of other gases. It is found in different concentrations depending on place and time, such as water vapor at a rate of 1% and carbon dioxide at a rate of (0.0314). [1]

When other compounds enter the air other than those mentioned previously, and when it carries elements that are foreign and excess to its natural components, the air then becomes polluted and harmful. Acquiring the character of pollution is due to the presence of chemicals in any form that leave harmful effects on the environment and the living organisms present in it, whether these pollutants are in a solid state. , liquid, gaseous, radioactive, or bacterial. Air pollution is then defined as the change in the characteristics and size of air elements as a result of the release of large quantities of particulate and gaseous pollutants, which leads to the transformation of many beneficial air elements into harmful and dangerous elements with a negative impact and damage on living and non-living organisms. It is any substance in the air that can cause Harm to humans and the environment. These pollutants may be in the form of solid particles, liquid droplets, or gases. In addition, these pollutants may be naturally occurring or resulting from human activity. [2]

Natural air pollutants:

- Forest fire smoke
- Ash and gases resulting from volcanic eruptions
- Gases such as methane that are emitted from decomposing organic materials [3]

Human air pollutants:

- Emissions from vehicles, fuel oils and natural gas for heating homes

- By-products of manufacturing and energy generation, especially coal-fired power plants[3[
- Car emissions.[2]
- #Most man-made elements of air pollution contain ground-level ozone, various forms of carbon, nitrogen oxides, sulfur oxides, volatile organic compounds, polycyclic aromatic hydrocarbons, and fine particulate matter.[4]
- Ground-level ozone O3: It is a special form of oxygen with its chemical formula (O3). Ozone forms a small part of our atmosphere, but it is very important for the planet Earth as it forms a protective layer to protect us from ultraviolet rays. Most of the ozone in the atmosphere is between (40-10) A layer above ground level is created when pollutants emitted by cars, power plants, industrial boilers, refineries, and other sources react chemically in the presence of sunlight.[4[
- Noxious gases: These are gases found in the autosphere, including carbon monoxide, carbon dioxide, nitrogen oxides, and sulfur oxides. They are emitted from mechanical vehicles and by-products of industrial processes.
- Volatile organic compounds (TOVC): They are organic chemicals with high vapor pressure such that large quantities evaporate and enter the atmosphere under normal conditions. They are usually called “organic” because they contain carbon. It is released through paints, cleaning materials, pesticides, some furniture and craft materials such as glue, apart from gasoline and natural gas, which are considered the main sources of volatile organic compounds that are released during combustion. [4[#
- Polycyclic aromatic hydrocarbons (PHA): It is a group consisting of more than 100 different chemical substances that are formed during the incomplete combustion of coal, oil, gas, garbage, or other organic chemicals such as tobacco or meat grilled with charcoal.[5] It is usually found as a mixture of two or more compounds, such as soot. A small number of them are used in medicines or in the manufacture of dyes, plastics, or pesticides.[4]
- PM: Fine particles consist of chemicals such as sulfates, nitrates, carbon, or mineral dust. The compounds are found in the combustion of fossil fuels, cigarette smoke, and burned organic materials such as forest fires. Fine particles also contribute to serious health problems.[4]

Indoor Air Quality (IAQ):

It is research into the components of indoor air that affect the health and comfort of residents in a building. Indoor air quality is vulnerable to pollution (mold, spores), chemicals (carbon monoxide, radon), allergens, or other solid pollutants that can affect health. Indoor air pollutants are associated with many health risks, including asthma. It has recently been proven that indoor air is more polluted than outdoor air, although this has not changed the common understanding of air pollution. In fact, indoor air is considered a greater health risk than outdoor air. [7]

Indoor air pollution is one of the most important environmental risks to public health around the world. Due to the increasing number of diseases associated with indoor air quality, studies have found that the concentration of pollutants in indoor indoor spaces is much higher than in the outdoor environment, with the increase ranging from two to two times. Five times, sometimes a hundred times higher than the outdoor pollutant level. Since most people spend 80% to 90% of their lives indoors, indoor air quality has a fundamental impact on public health.[6]

Using ventilation to expand contaminants, using filters, and adjusting the air supply are the primary methods for improving indoor air quality in most buildings. The lack of ventilation in closed spaces helps to concentrate the percentage of polluted air in these places where people spend most of their time. Indoor air pollution has been known since

ancient times, specifically in rural areas where coal, wood, and agricultural and animal waste are widely used as fuel. The types of indoor air pollutants differed. With the presence of modern buildings, and at the global level, the spotlight was not shed on indoor pollution until the end of the seventies of the last century, when complaints began to increase in some developed countries of various disease symptoms that occur inside air-conditioned and tightly sealed buildings, especially since people spend more than 80% of their day In closed environments, air-conditioned and sealed homes and buildings in particular cause many diseases, and the disease symptoms resulting from or related to indoor air pollution are called building sickness syndrome. Studies have shown high concentrations of various pollutants inside buildings, including cigarettes, dust, chemicals emitted from synthetic carpets and paint, in addition to other pollutants.

The symptoms of building sick syndrome are headache, dizziness, fainting, sleep-related restlessness, rhinitis, chronic nasal congestion, and skin rash. These symptoms should be temporarily associated with being in the building and disappear when the person is not in the building and can be found in a number of Individuals inside the building.[7]

Construction-related diseases:

It is a group of disorders whose cause is linked to the environment of modern, hermetic, energy-efficient buildings. These buildings are characterized by tightly sealed windows and reliance on heating, ventilation, and air conditioning (HVAC) systems to circulate air. Most cases occur in non-industrial office buildings, but illnesses can occur in apartment buildings, single-family homes, schools, museums, and libraries. Construction-related illnesses result from exposure to materials inside tightly sealed buildings with poor ventilation. Symptoms vary based on the cause but may include fever, difficulty breathing, runny nose or congestion, headache, skin problems, and difficulty concentrating.

Diagnosis involves assessing the air quality in a building and determining how many people typically have building-related symptoms. Treatment usually involves removing patients from the building or improving the air quality inside the building. Common causes are insufficient ventilation, chemical contaminants from internal sources, and chemical contaminants from external sources.

-Inadequate ventilation: Most buildings were not tightly closed and the air was circulated frequently, but after the energy crisis, buildings became more efficient in using energy by closing areas where air leaks into and outside the building. In addition, the air flow in many buildings decreased by 15 feet. cubic feet per minute to 5 cubic feet per minute.

-Indoor chemical pollutants: Common chemical pollutants inside a building are found in computers, copiers, paint, adhesives, carpets, cleaning agents, and upholstered furniture. These chemicals can emit volatile organic compounds (TVOC).

-External chemical pollutants: Common chemical pollutants from outside the building can include exhaust from cars and other industrial facilities in the area.[7[

Therefore, building owners must maintain the indoor air quality of the building by providing an appropriate ventilation system for gas emissions, smoke, polluted air, and heat resulting from various activities in the closed spaces of the building, and renewing the indoor air in accordance with the approved standards and not exceeding the acceptable percentages for indoor air quality and striving to control these percentages. And take measures to maintain indoor air quality.[6[

Include

-1Organic compounds: compounds that contain hydrogen and carbon bonds in their basic molecular structure. By origin, it usually comes from oil, coal and natural gas. They are natural products or synthetic materials. Pollutants may exist in three states: gas (vapor), liquid, and solid.

-2Inorganic compounds: compounds that contain carbon and hydrogen bonds in their molecular structure. The most important gaseous pollutants polluting the air include carbon oxides, sulfur

oxides, nitrogen oxides or ammonia and other compounds that play a fundamental role in air pollution.[1[

-3Particulates: This includes soot and ash from mining areas and dust from industrial processes. This means that particulate air pollution results from resource inputs from a large number of human activities. The amount of particles emitted from the atmosphere is estimated at about 180 thousand tons annually, in addition to particles resulting from natural processes such as volcanic eruptions and natural forest fires, as particles have bad effects on human health, especially on the health of the respiratory system and some other parts of the body.[2[

-4Biological pollutants: There are many biological pollutants in the environment that surround us, which are referred to as microbes or microorganisms, which are tiny particles of living organisms produced from several sources. Therefore, long-term exposure to high concentrations of biological pollutants causes a great risk to human health.[20[

Sources of indoor air pollution:

Air pollutants inside buildings, resulting from the building itself and the furniture it contains, can be classified into:

-1Gaseous pollutants: Air pollutants accumulate and accumulate inside closed spaces to a high degree as a result of the lack of ventilation in those places. It includes carbon monoxide gas (CO2), which is known as toxic, as it is emitted from coal and wood stoves, cigarettes, candles, and kerosene heaters. As for carbon monoxide gas (CO2), its concentration increases in places where ventilation is weak and crowded with people, which leads to an increase in the amount of carbon dioxide gas and a decrease in its quantity. Oxygen through the process of breathing (inhalation and exhalation) and consuming the amount of oxygen in that space in a way that exceeds the renewable amount of air in it. As for nitrogen dioxide gas (NO2), it is inhaled through our use of cooking stoves and heaters in which kerosene is used, which were widely used in all homes. The same applies to hydrocarbon gases that are emitted from the process of cooking food indoors and elsewhere.

-2Building materials and furniture: VOCs are emitted from building materials, architectural furniture, and carpets. Examples include radon concentrations in building floors, which are caused by building materials such as (stone, cement, soil, and fine dust). Lead is found in wall paint, which decomposes into dust that we inhale and thus has a significant impact on human health. Formaldehyde is emitted by wood, glue-coated furniture materials, insulation and wallpaper. Glue and adhesives emit volatile organic compounds such as acetone or methyl ethyl ketone. Equipment such as cameras, laser printers, and fax machines also affect indoor air quality, as do chemicals emitted from cosmetics, disinfectants, air fresheners, pesticides, and all household cleaners.[8[

-3 Biological pollutants: such as mold, bacteria, viruses, pollen, dust mites, animal dander, and many other pollutants, which can enter the home from outdoor areas, as the growth concentrations of these pollutants increase in humid environments, which can make an individual sick. Therefore, the humidity in closed spaces must not exceed 50%, and moisture-absorbing materials must be used to maintain the indoor air quality index within normal limits.[9]

4-People: Many pollutants are emitted from people and animals through breathing, sweat, and odors, such as acetone gas, ammonia, carbon dioxide, carbon monoxide, methane, and propane.

Wood stoves, space heaters, water heaters, space heaters, dryers, and fuel-burning combustion appliances in the home also cause indoor air pollution. All of these unvented or poorly ventilated fuel-fired appliances put out dangerous carbon monoxide as well as nitrogen dioxide. There is still Billions of people use these types of fuels to heat their homes on a daily basis.

-6Formaldehyde: It is another major cause of indoor air pollution. Formaldehyde is a colorless gas with a characteristic pungent odor and is no longer produced in the United States due to its ban in 1970, but it can still be found in paints, sealants,

and wood floors. Formaldehyde is used in carpets and upholstery. As a permanent adhesive.

10-Radon: which can be found under buildings in various types of bedrock and other building materials and even in water and can also be a cause of indoor air pollution. Radon can enter the walls of a building and expose individuals to the risk of developing lung cancer.[4[

4-2Pollutants studied:

1-4-2Carbon monoxide (CO): It is a colorless, flavorless, and odorless gas. It results from the partial oxidation process (incomplete combustion of carbon) and organic compounds such as coal. This occurs when oxygen is scarce, or when Combustion with a very high temperature. It is considered a highly toxic gas. It is a form of carbon, as well as some oils and greases from machines and vehicles. It is a heterogeneous diatomic particle because it contains two different elements, carbon and oxygen. This gas can also burn, and its combustion process is completed Which was originally - as we mentioned - incomplete, and it emits a blue fire because it combines with hemoglobin in the blood in the lungs when inhaled, forming carboxyhemoglobin, thus preventing the transfer of oxygen to tissues and cells, and when exposed to it, some symptoms appear on the body, such as a change in the color of the skin and mucous membranes. To redness and many other symptoms. Carbon monoxide poisoning can be treated by sufficient exposure to pure oxygen for a long period, and most importantly, stopping exposure to the source of the toxic gas CO, or transfusing red blood cells if necessary. To maintain safety, this gas must be eliminated By ventilating its locations, as there are many chemical treatments that are sufficient for the purpose. [10] It is unlikely that very high levels of carbon oxide will occur outdoors. However, its levels increase in the open air, and it can be a source of concern, especially for people who suffer from From some heart diseases.[11[

-confiscation:

This gas may leak from any of the following sources:

-1Gas stoves.

-2Gas-operated clothes dryers.

-3Gas water heaters.

-4Grills that operate with gas or charcoal.

-5Generators powered by gas or diesel.

-6Motor-powered boats.

-7Motorcycles.

-8Gas-powered landscape devices.

-9Gas or oil heater.

-10Some types of cigarettes.

-11Exhaust from cars, trucks or buses from attached garages, adjacent roads or parking areas

-12Combustion devices that are worn out or have been poorly modified and maintained, such as (boilers and furnaces). [11][10[

Symptoms of carbon monoxide poisoning:

The symptoms of carbon monoxide poisoning are very similar to those affecting the central nervous system. It is important to consider the case of carbon monoxide poisoning when one of the above sources is present around the affected person, and he will show the following signs- :

•If it is in low concentrations:

Headache, nausea, vomiting, blurred vision. [10[

•If it is in moderate concentrations:

Shortness of breath, poor vision, tachycardia, chest pain, and fainting.[10[

•If it is in high concentrations:

Palpitations, low blood pressure, respiratory arrest, coma, fatal at very high concentrations.[10]

Symptoms of exposure to formaldehyde also include:

Irritation of the nose, ears, and throat, nausea, sneezing and coughing, inability to concentrate, tears, shortness of breath, death from severe exposure.

To prevent significant sensory irritation in the general population, an air quality guideline value of 0.1 mg/m3 is recommended as an average over

a 30-minute period. Because this is more than one order of magnitude below the assumed threshold for cytotoxic damage to the nasal mucosa, this indicative value represents a level at which a minimal risk of upper respiratory tract cancer in humans is exposed.[17[

Total volatile organic compounds (TVOC:

VOCs include a variety of chemical gases emitted from solid objects or liquids, some of which may have short- and long-term adverse health effects. Concentrations of many VOCs are consistently higher indoors (up to ten times) than outdoors. Thousands of household products commonly used daily contain VOCs. Burning fossil fuels also releases volatile organic compounds into the atmosphere.[19[

Common emission sources of VOCs include:

Natural sources: such as respiration by living organisms and biodegradation, also release volatile organic compounds into the atmosphere.

Industrial sources: such as body shops for automobiles, trucks, buses, paint and industrial coating operations, paints and paint strippers, other solvents, wood preservatives, furniture, detergents and disinfectants, insect repellents and air fresheners, fuel and stored automotive products, dry cleaning of clothes, cosmetics, candles.

Volatile organic compounds (TVOC) are important pollutants because of their contribution to the formation of ground-level ozone. When VOCs are released into the atmosphere, they react with nitrogen oxide to form ozone molecules. Ultraviolet rays emitted by the sun speed up the reaction, which is why ozone production is higher. Ground-level ozone On hot, sunny days, ground-level ozone can have significant impacts on human health, and is the main pollutant that causes smog.[19[

Ground-level ozone can irritate the eyes, nose, and throat and can exacerbate asthma and other lung diseases, including bronchitis. Exposure to high levels of ground-level ozone can increase the risk of premature death in individuals who already suffer from heart disease. Or the lungs. Children, whose lungs are still forming and many of whom spend a lot of time outdoors, are particularly at risk in light of high ozone concentrations.

Exposure to VOCS itself can cause a variety of health effects, including:

•Irritation to the eyes, nose and throat.

•Headache and loss of coordination.

•nausea.

•Damage to the liver, kidneys, or central nervous system.

Some VOCS are suspected or proven carcinogens.[9]

Materials and Methods:

•Air quality detector: It is a simple but powerful air quality detector. This device combines ease of use and performance, providing exactly what we need to stay up to date on the air quality levels in our locations.

Electrochemical Sensor (DART) The Air quality monitor is engineered with Electrochemical Sensor Technology (DART) with a combination of factory testing, calibration and CE compliance providing us with accurate, trustworthy measurements. It will show us the slightest fluctuations in air quality. It allows you to take timely measures to maintain air quality within safe levels that preserve our health at home, office, school, car, hospitals, and other places.[10[

•Details of the device used:

-1It has a large (5.5) inch screen and a large display that makes it easy to read data, pollution level, comfortable division, and easy operation of buttons.

-2Monitoring indoor air quality built into electrochemical sensors (DART) can accurately detect multiple gases: carbon monoxide (CO), carbon dioxide (CO2), formaldehyde and volatile organic substances.

-3Suitable for many places, as it is easy to carry and suitable for homes, cars, offices, and many other environments, and provides 24-hour real-time monitoring to protect healthy life.

4- Permanent power, it has three colors that express its power level with a battery power display screen, which is more convenient to use, and a built-in polymer battery, saving battery and protecting the environment. Three hours of charging is enough for continuous use for four hours and more, and continuous monitoring of the air during charging to ensure Detect air quality problems in time.

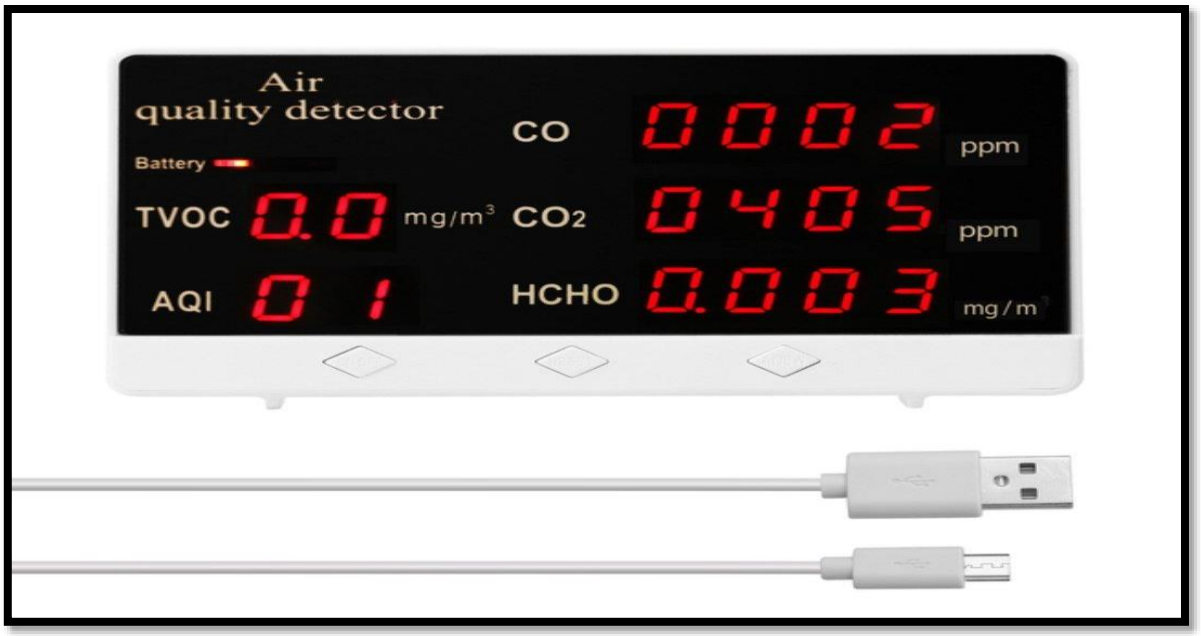

Figure (1): Air quality detector device.

Device features:

-1Multifunctional: It detects formaldehyde, carbon monoxide, carbon dioxide, and total volatile organic compounds.

-2Easy to operate and understand.

-3More accurate with sensors.

-4Rechargeable and portable.

-5It gives real-time readings.

Results and Discussion:

In this chapter, the measured values are interpreted based on the air pollution level reference table below. Al-Sadr Teaching Hospital is crowded with people. It should also be noted that each site contains many sources of pollution from which compounds are constantly emitted, even if the values vary. We may not feel them sometimes, and their occurrence occurs in a cumulative manner in the body, and some of them have visible symptoms. These compounds have many sources, including medical and electronic devices, leather covering chairs, lighting sources, wooden tables, detergents, and others.

Table (1): Reference table for air quality pollution level.

فئة المؤشر	AQ	HCHO	CO^2	CO	TVOC
ممتاز	1	0_0.08	0_450	0_50	0_0.08
جيد	2	0.081_0.1	450_1000	51_100	0.5_0.6
تلوث طفيف	3	0.101_0.2	1001_1500	101_200	0.6_1.5
تلوث معتدل	4	0.201_0.5	1501_2000	201_400	1.5_3.0
تلوث شديد	5	0.501_1.0	2001_3000	401_800	3.0_6.0
تلوث خطير	6	1.001_1.999	3001_5000	801_2400	6.0_12

- Barcode room: In general, it showed a good contamination value, but it may increase the longer the stay
- Waiting hall: Due to the large numbers that were present at the time, the measurement results showed a severe pollution category in the air quality index, and the high percentage of CO2 is attributed to the increase in breathing rates in the hall.[12
- Pharmacy: With only 4 pharmacists, the air quality index percentage was within the good range.
- Resuscitation: The intensity of pollution increased to very dangerous levels due to the rise in all concentrations to high levels, as the resuscitation was a large hall with several beds, each bed separated by a curtain, in addition to the fact that the patients' families were also inside, with there not being a sufficient ventilation system to change the condition. In the air, breathing rates affected the percentage of CO2 and TVOC [12][19]. The use of detergents and disinfectants also contributed to increasing TVOC concentrations, and the high concentration of HCHO is due to the presence of electronic devices and equipment there.[17[
- Incoming and outgoing room: The percentage of measured compounds was moderate and not contaminated, but due to the small area of the room and the lack of sufficient ventilation, it led to the accumulation of TVOC inside the room from plastic and furniture.[19[
- Printer room: The printer room showed a good air quality index category within the range of excellent and good percentages as a result of ventilating the room and changing the air components.[7[
- Maintenance room: The air quality index category was severe due to the high concentrations of volatile organic compounds due to the presence of furniture that emits gases.
- Director's Secretariat Office: Due to the small area of the room and its containing furniture made of leather, it gave a serious pollution value in the Air Quality Index category, an increase in TVOC concentration, and a slight increase in the percentage of formaldehyde (HCHO) due to cigarettes and the use of scented detergents to clean the floor.[19] [18[
- The director's office: a hotbed of pollution due to the fact that his room is small and contains refrigeration equipment and electronic devices, and due to the small area of the room and the fact that it contains several people smoking and the use of detergents, all of these reasons led to recording the highest pollution values in the Air Quality Index category.[19] [17] [18[
- Women's bathrooms: The air quality was very poor because the place was very small and did not contain any ventilation opening to change the air components.[6[
- Men's bathrooms: The percentages of the measured compounds showed within normal limits at the normal and excellent levels (according to the reference table). The air quality was good because the place was very ventilated.[7[
- Cafeteria: The concentrations of the measured compounds showed within normal limits at the good and excellent level, but the cafeteria furniture, including chairs made of wood and leather, wooden tables, and their use of air fresheners, led to an increase in TVOC levels.[8[
- Medical Equipment Unit: The values of the measured compounds increased due to the small area of the room, in addition to the furniture composing the room, the presence of electronic devices, and the lack of a suitable ventilation system to reduce the accumulation of emitted gases, so the air

quality index category was dangerous.[6][17][19[

- Medical Equipment Workshop: It is a very small room containing large quantities of devices, equipment, and plastic and metal materials, in addition to the presence of soot resulting from equipment maintenance operations there. All of this helped in recording slight pollution concentrations of the measured gases, in addition to the lack of appropriate ventilation systems to reduce the accumulation. Emitted gases. [2] [17[
- The urology consultation: The values within the urology consultation were excellent, that is, within the range of good and excellent levels (according to the classification of the reference table), and thus the air quality was not polluted because the place was empty at the time.
- Consultant Neurosurgery: The air quality index category was good and not polluted because the place was empty at the time, which reduced the increase in breathing rate and other gases.
- Thoracic and Vascular Surgery: The intensity of pollution increased to dangerous levels due to all values rising to high levels due to the use of detergents and air fresheners inside the consultancy, which led to the release of total volatile organic compounds and recorded a noticeable pollution in the concentration of HCHO and thus affected the air quality index category and was dangerous. [8]
- Surgical emergencies: The air quality index category was high as a result of the increase in the number of visitors, the fact that the place was closed (no ventilation system), and the use of detergents and sterilizers to kill bacteria, which led to an increase in the percentage of formaldehyde and because of the increase in breathing rates (exhalation), which in turn affected the CO2 percentage.[12][18[
- Internal Emergency: We note that the air quality index category has risen to a dangerous value due to the significantly high concentrations of all measured gases, as the TVOC was dangerously high due to the electronic devices there and the furniture consisting of leather-covered chairs and wooden tables, and the HCHO concentration was very high and dangerous due to the use of disinfectants to sterilize the floor. The tools and the presence of large numbers of auditors in addition to doctors and nurses led to increased breathing, which in turn gave rise to a high concentration of CO2 gas.[8][18][12[
- Dermatology Consultant: The measured gas concentration values were normal due to the presence of a suitable ventilation system inside the place and that it was free of auditors at the time, so the air quality index category was good.[7[
- Laboratory staff room: The air index category showed poor and highly polluted levels because the room was very small in size and used for resting staff only. It did not contain any ventilation opening to change the air components. More than (5) people were sitting in it, which led to an increase in the respiratory rate that In turn, it led to an increase in the concentration of CO2 and TVOC to a high and dangerous pollution value.[7][12][19[
- Microbiology Unit: The air quality index category was of slight pollution (according to the reference table) because the place had windows, which are considered a good ventilation system for changing the components of the air, and its absence of auditors contributed to recording these normal percentages.[7[
- Virus unit: The air quality index category was within the good range (according to the reference table.(
- Magnetic resonance unit: The lack of a suitable ventilation system in addition to it

being always closed, which led to the accumulation of pollution particles in the air in addition to toxic gases emitted from electronic devices and the resonance machine, which led to the air quality index category being very poor and a high TVOC concentration.[8][19[

- Magnetic resonance unit corridor: It is a narrow corridor containing chairs for patients to sit in addition to being very crowded by them, which led to a high concentration of TVOC, and the air quality index category was dangerous, but the concentrations of the rest of the gases were within average limits due to the number of people and the increased breathing rate. [12]][8[
- Laser unit: Due to the presence of medical devices and cooling devices, and the fact that the room is always closed, does not contain a ventilation system, and contains a table made of artificial wood and leather covering the surfaces of the chairs, all of these reasons led to high concentrations of HCH and TVOC, so the air quality index category was dangerous. [8[
- Dental Implant Unit: We notice that the value of the air quality index has risen to a dangerous value in addition to the high concentration of TVOC due to the presence of medical devices used and the use of sterilizers to sterilize disinfectants from bacteria, which has increased the concentration of HCHO.[18][17[
- Virus Division: The concentrations of gases within the division were within the average range, and thus the air quality index category was moderate (according to the reference table.(
- Blood Drawing Division: The air quality appeared at poor and highly polluted levels due to the use of sterilizers, air fresheners, and detergents, in addition to chairs made of leather, which led to a high percentage of TVOC and HCHO.[18][8[
- Parasitology Division: The concentrations of measured gases were normal and not polluted, so the air quality index category was good.
- Tissue Examination Division: The air quality index category was within dangerous levels due to the significantly high concentrations of all measured gases, as the TVOC percentage was dangerously high due to laboratory equipment, the use of sterilizers and detergents used, in addition to the wall paint. We also notice an increase in the level of CO2 due to an increase in the respiratory rate.[8][12[
- Radiology Division: The air quality index category was good because it was not crowded during the measurement period, so the concentrations of all gases were within the normal range.
- Kidney Laboratory: The air quality was very poor. The reason was that the laboratory was small, closed, crowded, and did not contain a ventilation system to change the air components. The use of leather-covered seats and the presence of electronic devices increased the TVOC percentage.[8[
- Culture media room: High pollution rates were recorded due to several reasons, including that it contains devices and tools used in cultivating bacteria. The presence of bacteria means the presence of microbial contamination that affects the indoor air quality, and that preparing and storing the media leads to the release of TVOC, in addition to the fact that the room does not contain any ventilation opening. The presence of (5) people inside it is considered one of the reasons that led to an increase in the CO2 concentration due to the increased breathing rate. [20][12]
- Blood diseases: The severity of pollution has increased to very dangerous levels due to the rise in concentrations of all gases to high levels due to the lack of a sufficient

ventilation system to change components and to the presence of devices that lead to the release of volatile organic compounds and formaldehyde, in addition to the use of sterilizers.[8[

- Radiation examination room: The air quality was good, unpolluted, and even a slight increase in CO2 concentration was due to an increase in breathing rate.[12[
- Operating room hall: The air quality index category was very poor due to the fact that the place was closed and full of patients, and this in turn caused an increase in the CO2 concentration due to the increase in the respiratory rate, and this would also cause an increase in the TVOC.[12[
- The first operating room (neurosurgery): The first operating room recorded normal concentrations of the measured gases, and thus the air quality index category was good (according to the reference table.(
- The second operating room (general surgery): The air quality appeared at poor and highly polluted levels due to the constant use of sterilizers to sterilize the medical tools used and detergents to clean the floor, which led to an increase in the TVOC concentration, and the increase in the CO2 concentration is due to the increase in breathing rates due to the presence of doctors and nurses.[12] [8][18[
- Third operating room (nose, ear, throat): Gas levels were within the good and normal range, and thus the air quality index category appeared as good, not polluted.
- Fourth operating room (urology): The measured gas values were within the normal range, and thus the air quality index category appeared as good, unpolluted, and even a slight increase in CO2 concentration was attributed to breathing.[12[
- Fifth operating room (urinary surgery): The room contained more than one patient at a time, which required the presence of a larger number of doctors and nurses. The presence of medical and electronic devices, metal tools, and the quality of the room's paint all contributed to the release of volatile compounds into the air and the increase in TVOC concentrations and even the resulting rise. in CO2 concentration because the room was crowded. [12][8[
- Sixth operating room (eye surgery): The operating room was empty and showed gas concentrations within excellent normal limits, and thus the air quality index category was good, not polluted at all
- Emergency operations hall: The air quality index category appeared as poor and dangerous due to the fact that the hall is closed and does not contain a ventilation system.[6
- Vascular catheterization operations: The concentrations of measured gases were within normal limits and were thus a good air quality index category (according to the reference table(
- The first and second men's surgery hall: The measured gas values appeared within an excellent range free of pollution, so the air quality was high due to the presence of an appropriate ventilation system.
- Third Men's Surgery Hall: The air quality index category was moderate (according to the reference table), so the concentrations of all measured gases were normal and good.
- Gynecological Surgery Hall/Room No. 103 and 107: The air quality index category was good, not polluted, as the place was devoid of equipment and was not crowded, in addition to the fact that the place was ventilated.[7[
- Floor 3/Women/Private Wing/Rooms 1 and 2: We note that the air quality index category is from good to very slight pollution value because the place is well ventilated and not overcrowded.[7[

- Floor 3/Women/Private Wing/Room No. 3 and 4: We note that the concentrations of measured gases are higher than normal values because the area of the room does not fit the number of people present, as there were 6 people inside with no proper ventilation system, and thus the air quality index category appeared as very poor. .[6[
- Floor 3/Women/Private Suite/Room No. 9: The air quality category was very poor due to the fact that the room was closed and did not contain a ventilation system, which led to the accumulation of organic compounds in the air.[8[
- Floor 3/Women/Private Wing/Room No. 10 and 11: The measured concentrations were within normal and good limits (according to the reference table) due to the presence of an appropriate ventilation system.[7[
- Floor 3/Women/Private Wing/Al-Kosour Lounge: The pollution value was very high even though the lobby was empty during the measurement period. The reason is that it was closed with no ventilation system, in addition to the existing furniture and wall paint, which led to the accumulation of total organic compounds. Volatile TVOC and pollution particles in the air.[8][19[
- Negative hemodialysis halls: We notice an increase in the measured gas values due to the fact that the hall was full of patients in addition to nurses, which led to an increase in the respiratory rate and the use of sterilizers and detergents to clean the floor, as it had a very strong odor, in addition to the presence of electronic devices that emit toxic gases, whether from a structure. The device or while it is operating.[17][8] [19[
- Positive hemodialysis halls: The hall has a high pollution value even if there are a small number of patients, and this is due to the presence of many electronic devices that emit toxic gases in addition to the use of detergents.[18][17]

Conclusions:

- The study revealed that the most polluted sites are those that contain electronic devices inside them, those that deal with microorganisms, and those that use detergents and sterilizers.
- A high percentage of total volatile organic matter and carbon dioxide was observed in some of the measured sites, even though they were empty, due to the lack of ventilation systems, which led to the accumulation of these gases.
- The lack of proportionality of the area of the place to the number of members or expatriates has a fundamental role in the decline in air quality.
- The presence of secondary reasons that helped increase the concentrations of some of the measured gases, because they are constantly emitted from the paint on the walls, the leather covering the wooden seats and tables, as well as the electronic devices, due to the lack of adequate ventilation systems for the place, which led to the accumulation of gases over time.
- The study revealed that the air quality index category ranges from (excellent to moderate) in places with good ventilation, and vice versa. In places that suffer from poor ventilation, the air quality index ranges from slight pollution to serious pollution.

Recommendations:

- Providing all Al-Sadr Teaching Hospital sites with sufficient ventilation systems to increase air exchange, especially those that contain electronic devices and those that deal with organic compounds, while ensuring that the ventilation system works appropriately and taking care to maintain it.
- Installing devices that detect air quality by sensing polluted gases in all closed places, whether in hospitals, laboratories, homes, offices, or other places, so that building owners are aware of the existing level of

pollution and take the necessary measures to improve it.

- Reducing the number of attendees in proportion to the size of the place.
- Choose the appropriate time when using heavily scented cleaners and air fresheners in enclosed spaces, while ensuring that there is appropriate ventilation to circulate the gases.
- Avoid using solvents in enclosed spaces, unless there is good ventilation, reading the instructions carefully and following the necessary safety precautions.
- Maintaining temperatures inside the building and keeping the building dry and isolated from moisture to prevent bacteria and mold from growing.
- Putting ornamental plants inside enclosed spaces to purify the air and absorb toxic gaseous pollutants by adding oxygen and removing carbon dioxide.
- Use means to purify the air, such as filters, and change them from time to time due to the accumulation of pollutants on them and it becomes a suitable environment for the growth of germs and microbes that can penetrate the filters and cause pollution of the closed space.

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