Towards A Design Approach to Achieve Environmental Safety in Diagnostic and Therapeutic Units in Hospitals Using Nanotechnology

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Abstracts: In The environmental safety was investigated in this study, with an initial focus on defining the general concept of environmental safety. Subsequently, the study delved into the environmental safety within hospitals, particularly in diagnostic and treatment spaces. Air pollutants and their types were examined, along with permissible levels, emphasizing the adverse effects of increased pollutants on human health. Additionally, attention was given to the physical hazards within these spaces, such as temperature, noise, and lighting. In the context of studying diagnostic and treatment spaces in hospitals, a review was conducted on the currently used traditional finishing materials and an evaluation of their harmful effects. The concept of "sick buildings" and its impact on human safety was also explored. The study placed a particular emphasis on nanotechnology and how nano-materials can be employed to mitigate the detrimental effects of non-compliant "sick buildings" with environmental safety standards. Global examples of nano-applications were analyzed, along with an examination of a hospital in Egypt that utilizes nano-technology in its glass structure. Furthermore, a simulation was performed on a local hospital to measure the difference in carbon dioxide emission within the space. This comparison was conducted between the current state of the building using traditional finishing materials and the scenario where nano-alternatives are employed in the glass and thermal insulation of exterior walls.

Keywords: Environmental Safety, Nano-Materials, Diagnostic and Treatment Spaces, Sustainable Healthcare Design.

1. INTRODUCTION

Achieving control over architectural space and creating a conducive indoor environment is not solely accomplished through the meticulous design of walls and floors, which constitute the building blocks. It also involves respecting the environment in which the building will be placed, as it will affect both the indoor and outdoor environments. In some instances, indoor environmental pollutants can adversely affect the pristine outdoor environment, leading to its degradation. In an era where human development spans various domains, individuals are compelled to allocate ample attention to both themselves and the indoor environment they inhabit.[1]

Since the discovery of pollutants and their impact on human health, studies have sought to understand the causes of these pollutants. The concept of "sick buildings" emerged as one of the most significant and dangerous forms of pollution, given the potential long-term effects, sometimes leading to the development of cancerous diseases. In 1984, the World Health Organization (WHO) reported that approximately 30% of modern buildings provide an unhealthy environment for their occupants, resulting in the manifestation of symptoms known as building-related illness (BRI).[2]

This heightened awareness prompted a shift towards environmental safety practices within buildings, particularly in hospitals. Environmental safety in hospitals is a vital component to improve the quality of healthcare and ensure the safety of patients and medical professionals.[3]

The increased release of carbon dioxide into the atmosphere during the 20th century led to the phenomenon of global warming, with a recorded temperature rise of one degree Celsius. Scientists concluded that at least half of this increase is attributable to human activities. Without substantial measures to address this issue[4], global temperatures are projected to continue rising by one to three degrees in the 21st century. In 1970, scientists also deduced that the ozone layer, which shields the Earth from harmful ultraviolet rays, is under threat due to certain chemicals used in refrigerators, air conditioners, and similar appliances. The consequences of ozone layer

depletion are severe, including an increase in skin cancer cases and a weakened immune system in humans.
The WHO's 1984 report reiterated that about 30% of modern buildings offer an unhealthy environment for their occupants, leading to the emergence of symptoms associated with Building Related Illnesses.[5]
This study aims to shed light on the impact of environmental health quality on patient treatment. With the advancements in recent research, a better understanding of environmental safety opens up new avenues to enhance healthcare institutions and comprehensively improve the patient experience.[6]

2. RESEARCH PROBLEM

According to the World Health Organization, the occurrence of adverse events resulting from inadequate healthcare is one of the top ten causes of death and disability worldwide. One out of every ten patients experiences harm while receiving healthcare, and such harm can result from a variety of adverse events, half of which are preventable. The lack of environmental safety in diagnostic and treatment spaces, often stemming from building design and execution by designers, constitutes a significant factor in the absence of safe healthcare. Healthy individuals and hospital staff are exposed to most of the risks and hazards faced by patients in medical institutions, including the spread of infections, noise, and heightened stress due to inadequate temperature and humidity levels, The use of some traditional finishing materials causes an obstacle to achieving environmental safety within diagnostic and therapeutic spaces because of their harm to public health.

3. THE IMPORTANCE OF THE RESEARCH

The research addresses a fundamental and vital topic, which is clarifying the danger of neglecting environmental safety during the building design process. It highlights that compromising on environmental safety or making it a secondary goal can lead to the loss of human lives or result in the compromise of well-being. This indicates that the optimal utilization of advancements and technological progress in building materials and design methods is not achieved when environmental safety is disregarded.

4. RESEARCH HYPOTHESIS

4.1. The continued use of unthoughtful building materials in diagnostic and treatment spaces leads to an increase in environmental damage.
4.2. The internal environment of the hospital significantly affects both the physical and psychological health of individuals, a matter of greater importance than typically acknowledged by designers and responsible entities when contemplating building design.

5. RESEARCH OBJECTIVES

5.1. Main Objective

Defining the Foundations and Criteria for Selecting Optimal Nanomaterial Finishes to Achieve Environmental Safety in Diagnostic and Therapeutic Units within Healthcare Buildings.

5.2. Secondary Objectives

5.2.1. Identifying the Conventional Materials Used in Finishing Architectural Elements within Diagnostic and Therapeutic Units that Negatively Impact Environmental Safety.
5.2.2. Analyzing the Negative Effects of Finishing Materials on Environmental Safety and Human Health, Particularly within Diagnostic and Therapeutic Units.
5.2.3. Accessing Environmentally Better Alternatives to Nano Materials to Enable the Selection of Construction and Architectural Materials for Diagnostic and Therapeutic Spaces.

6. DEFINITION OF ENVIRONMENTAL SAFETY7

It is the science that concerns the preservation of human safety and health by providing secure work environments free from causes of accidents, injuries, or diseases.
Another definition: It is a set of engineering, organizational, and educational methods aimed at protecting humans and property.
In short, it is the preservation of the natural environment from the negative impact of human activities.

7. SICK BUILDINGS

7.1. Definition of Sick Buildings:

Sick buildings refer to indoor spaces that negatively impact the health and well-being of their occupants. These buildings often lead to discomfort, health issues, and problems that can be attributed to various environmental factors inside the structure.[8]

7.2. Impact Of Sick Buildings

7.2.1. Impact On Occupants[9]

The field of medicine is no longer just linking diseases to viruses and microbes but also associating them with various environmental phenomena. These phenomena can be chemical (organic or inorganic), biological (dust, bacteria, etc.), or physiological (heat, light, electromagnetic fields, noise).
7.2.1. Studies have shown that exposure, even to low doses of toxins and pollutants, has harmful effects and risks similar to exposure to high doses, leading to conditions such as fatalities, organ damage, paralysis, cancer, and birth defects.
7.2.2. Exposure to very low doses of various manufactured chemicals can result in deficiencies in human vital functions, such as cognition and the activity of glands responsible for hormone production in the body, determining tissue response to these substances.
7.2.3. The presence of silica in many materials such as sand, bricks, Portland cement, ceramic tiles, and some types of stone affects the respiratory system and causes long-term Chronic Obstructive Pulmonary Disease (COPD).[10]
7.2.4. Lead in paints, drainage pipes, and welding materials, prevalent in buildings constructed before 1970, has been shown to contribute to psychological disorders like depression and anxiety at low levels of exposure and can lead to organ damage, such as the kidneys.
7.2.5. Some insulation materials contain asbestos, mainly found in vinyl flooring, floor wax, and other adhesives, commonly used in buildings constructed before the mid-1980s. Studies confirm the negative respiratory effects of asbestos, causing a condition known as asbestos-related pleural disease, a carcinogenic substance.
7.2.6. Glass wool used in insulation materials and also in plastic manufacturing has been proven to cause irritation to the eyes, skin, and respiratory system.
7.2.7. Cadmium, used as a rust-resistant substance in various electrical devices and paints, has been identified by studies as a carcinogenic substance.[11]

7.2. Factors Affecting Indoor Pollution (Causes of Sick Buildings)[12]

7.2.1. Building Location.
7.2.2. Multiple Sources of Pollution inside the Building, such as various materials emitting particles or toxic gases.
7.2.3. Temperature and Humidity, affecting the rate of environmental pollutants. Damp and poorly maintained areas facilitate the growth of mold, bacteria, and the spread of biological pollutants.
7.2.4. Type and Nature of Activities inside the Building, such as smoking, painting operations, or the use of sprays, aerosols, and cleaning products.
7.2.5. Type of Insulation Used in the Building and its impact on heat, sound insulation, and energy consumption.
7.2.6. Air Movement inside the Building and Air Exchange between the Building and the External Environment. Poor ventilation leads to the accumulation of pollutants inside the building, which can be inhaled.

7.2.7. Natural Lighting and the Size of Openings (Sunlight helps eliminate bacteria, some pollutants, and viruses).

8. SOME DAMAGES OF TRADITIONAL FINISHING MATERIALS USED INSIDE DIAGNOSTIC AND TREATMENT SPACES:

8.1. Emission of Harmful Compounds: Traditional finishing materials may emit harmful compounds, including volatile organic compounds (VOCs) and formaldehyde, which can negatively impact indoor air quality.
8.2. Mold Growth: Certain traditional finishing materials may be prone to mold growth, especially in environments with high humidity. Mold can lead to health issues and compromise the overall hygiene of the space.
8.3. Toxic Elements: Some materials might contain toxic elements, such as lead or asbestos, posing health risks to occupants. Exposure to these substances can lead to severe health problems over time.
8.4. Environmental Impact: Certain traditional materials might not be environmentally friendly, contributing to sustainability concerns in healthcare facility design and management.

Table 1. Shows the drawbacks of using traditional finishing materials inside diagnostic and therapeutic spaces.

Subject	Emitted pollutants [14] [15]	Impact on health	CO2 emission rate [13] Kg Co2/ metric ton
Tiles	Formaldehyde and some types of tiles contain the carcinogenic substance asbestos.	Irritation to the eyes, nose, throat and lungs and may cause formaldehyde poisoning, carcinogenic substance.	430
Ceramic	High levels of radiation can result from one of the components of ceramic or from the glazing layer due to its content of the radioactive substance zirconium.	Destruction of brain tissue	0.74
Marble	Some materials, depending on the extraction regions, can exhibit high levels of radiation activity, particularly in areas rich in radioactive elements.	Radiation contamination may occur and increase the risk of cancer	0.116
Wood in general	The problem lies in the varnish material used for surface treatment, which emits volatile organic compounds (VOC). Additionally, it clogs the pores of the material, leading to the appearance of mold and allowing the growth of bacteria, which can cause various diseases.	VOCs are carcinogenic and cause endocrine disruption	0.30+0.41
HDF	It contains chromium and arsenic, both of which are toxic substances. Additionally, it emits formaldehyde gas.	Stomach disorders, ulcers, breathing disorders, and a weak immune system.	0.51+0.54
Cement tile	Some types of cement are highly radioactive.	Radiation contamination may occur and increase the risk of cancer	0.215
PVC Flooring	Emission of formaldehyde and volatile organic compounds (VOCs).	A carcinogenic substance that causes endocrine problems	4
Linoleum made from flaxseed and free of chemical compounds	Considered less harmful than vinyl flooring, but its main problem lies in the pollutants resulting from the adhesives used in its installation, such as amines, ethylbenzene, formaldehyde, and octane.	may cause formaldehyde poisoning, carcinogenic substance.	1.21
Nylon Carpeet	Emission of some volatile organic compounds (VOCs), as well as formaldehyde gas and many other pollutants such as ethylbenzene, trimethylbenzene, and others.	A carcinogenic substance that causes endocrine problems, and may cause formaldehyde poisoning, carcinogenic substance.	6.7-19.7
Wool Carpet	The spread of various types of mold, as well as numerous insects. Additionally, dust and particles resulting from friction spread in the air, causing several negative effects, especially for individuals suffering from asthma.	Allergies, affecting the respiratory system, causing serious diseases such as asthma and allergies, and helping to spread germs.	5.48

9. THE PROPOSED NANOTECHNOLOGICAL ALTERNATIVES TO TRADITIONAL FINISHING MATERIALS.[16 17]

The material	Definition	Its advantages	Its impact on environmental safety
Nano Wood	The nanotechnology treatment may involve the infusion of nanoparticles into the wood structure or the application of nanocoatings on its surface.	- Dust-resistant and repellent. - Resistant to vapors and highly heat-resistant. - Preserves the natural color of wood. - UV-resistant and weather-resistant, withstands temperatures, corrosion, and cracking. - Resistant to algae, bacteria, and fungi, easy to clean. - Strong and durable material capable of withstanding conditions like concrete, environmentally friendly.	- Reducing the use of environmental resources. - Easy to clean, reducing the consumption of chemical detergents. - Improving air quality does not cause the emission of harmful substances
Nano aluminum	It has been processed using nanotechnology, where aluminum is converted into very small particles at the nano level. It allows modification and improvement of the physical and chemical properties of aluminum through advanced technological methods.	- Composite aluminum panel is characterized by its lightweight, high strength, and corrosion resistance. - Smooth surface with high smoothness of up to 80%, thermal insulation, and sound insulation. - It is durable, making it suitable for indoor furniture without the harmful effects of regular aluminum and anti-corrosive paints that may contain carcinogenic substances such as cadmium.	- Improving air quality does not cause the emission of harmful substances. - It helps with thermal and noise insulation, providing a non-disturbing indoor environment and contributing to temperature balance when used in windows. - Easy to clean, reducing the consumption of chemical detergents.
Nano glass[18]	Nano glass is treated with nano coatings and insulation layers between its layers.	- It clearly limits unwanted permeability properties, providing flexibility for designers to create suitable spaces for openings in buildings. - Provides natural lighting and a suitable climate for interior spaces. - Some types work to remove pollutants and dust deposited on the exterior glass, making it self-cleaning. - Scratch resistant	- Easy to clean, reducing the consumption of chemical detergents. - Proper thermal insulation with adequate lighting. - Fire-resistant - It resists acids, chemical compounds, and organic substances. - Non-reflective, anti-glare, and some types purify the air, eliminating external and internal pollutants.
Nano coatings[19]	They are thin layers of materials containing nanoparticles. These coatings are designed using nanotechnology techniques to achieve unique properties and effectiveness in improving the performance of the surfaces treated with them.	- It is used to purify the air in buildings and also to protect surfaces from bacteria and fungi - It does not cause infection. - Some nanocoatings may have properties such as protection against ultraviolet radiation, reducing the harmful environmental impact. - Some nanocoatings can enhance the slip resistance of surfaces, which can be beneficial in applications such as glass and ceramics.	- Non-reflective, anti-glare. - Easy to clean. - Fire-resistant. - Scratch resistant. - It helps improve air quality, as it does not cause the emission of harmful pollutants from ordinary paints, such as volatile organic compounds. Some types of paints help in purifying the air and killing bacteria present in the air.
Nano insulation	Nano-insulation materials are substances that have been enhanced using nanotechnology techniques to improve the physical and chemical properties of the materials. They are primarily used in the fields of thermal insulation and sound insulation to enhance insulation efficiency and achieve better performance.	- Nanotechnology-enhanced insulation materials achieve 30% higher efficiency compared to traditional materials, and they use fewer non-renewable resources than older insulation materials. - Its high thermal insulation capability and the provision of natural lighting for transparent types make it valuable. Additionally, it is lightweight.	- Low thermal conductivity provides high thermal insulation. - Long lifespan, requiring minimal maintenance or replacement. - Does not produce harmful emissions and reduces the carbon dioxide emission rate. - Reduces the need for using chemical cleaners that emit harmful substances to human health.

10. DESIGN PRINCIPLES AND STANDARDS FOR ACHIEVING ENVIRONMENTAL SAFETY IN DIAGNOSTIC AND TREATMENT SPACES[20 22 21]

1. Design therapeutic spaces away from areas with noisy equipment.

2. Utilize internal courtyards to maximize natural lighting, ventilation, and insulation from external noise.

3. Consider optimal spatial orientation for natural ventilation, minimizing the use of mechanical ventilation to reduce greenhouse gas emissions and ambient air temperature.

4. Study wind patterns during building design and optimize their use for required ventilation in each space.

5. Increase the number of external openings to establish direct connections with the external environment and provide natural lighting without relying on non-renewable energy sources.

6. Analyze the number of space users during design to assess its impact on required ventilation, temperature, and humidity.

7. Avoid significant variations in lighting and noise levels between adjacent spaces.

8. Optimize the design to minimize the consumption of non-renewable energy, replacing it with renewable energy sources.

9. Depend on natural resources and reduce the use of non-renewable energy, as environmental safety extends beyond the building's internal boundaries.

10. Use materials with low carbon footprint that do not emit carbon during building use.

11. Implement nano-treated lighting in operating rooms, aiding in bacteria elimination.

12. Choose finishing materials that do not emit harmful substances causing health issues, unlike some traditional finishing materials.

13. Employ materials that reduce glare and reflection.

14. Rely on finishing materials that aid in air purification within indoor spaces, not the opposite.

15. Minimize air conditioning usage to reduce greenhouse gas emissions and heat release.

16. Seal diagnostic space walls and doors without openings; it is advisable to use mechanical ventilation rather than natural ventilation in these spaces.

17. Thermally insulate external facades and building surfaces to reduce heat loss.

18. Use heat-insulating construction materials or add insulating layers to walls for balanced internal heat preservation without mechanical heat treatment.

19. Use treatments that do not emit harmful substances to the internal or external environment.

20. Provide natural ventilation independent of mechanical air circulation to avoid potential sources of germs, bacteria, and pollutants.

11. THE MOST IMPORTANT FINISHING REQUIREMENTS THAT CAN BE MEASURED TO ENSURE ENVIRONMENTAL SAFETY INCLUDE

Spaces	Outpatient clinics	Radiology departments	Analysis labs	Emergency departments	Operating rooms	Physical therapy	Radiation therapy
Finishing Requirements							
Glass							
Low thermal conductivity							
Does not cause heat loss							
Provides natural light without transferring heat							
Contains a thermal insulation layer that does not affect lighting							
Anti-condensation and fog							
Provides a clear view of the external environment							
Noise insulating							
Fire-resistant							
UV non-permeable							

Easy to clean							
Self-cleaning							
Insulation							
External wall insulation							
Lead-shielded radiation space insulation							
Use materials that do not significantly increase wall thickness							
Lightweight, does not impose a load on the building							
Wall Finishing							
Does not emit harmful emissions							
Helps purify the air							
Non-bacterial							
Does not cause glare							
No need for chemical cleaners (easy to clean)							
Does not cause infection transmission							
Does not cause sound reflection							
Floors							
Non-reflective to light							
Non-reflective to sound							
Does not emit chemical pollutants							
Does not cause infection transmission							
Helps purify the air and kill bacteria							
Does not cause slipping and sliding							
Easy to clean							
Indoor Furniture							
Self-cleaning, does not cause infection transmission							
Does not cause sound reflection							
Does not cause falling and injuries to users							
Ventilation							
Quality of outdoor air							
Building block design to avoid wind vortices							
The external air source does not pass any pollution source							
Natural ventilation in labs and mechanical ventilation							
Use exterior paints that purify the air							
Ceilings							
Does not cause light reflection							
Antibacterial							
Dirt and dust resistant							
Absorbs sound							
Self-cleaning							
Lighting							
Provide sufficient natural lighting for the space							
Openings should not be less than 0.1 of the space area							

12- HOSPITALS HAVE APPLIED NANO FINISHING MATERIALS

12.1. Manuel Gia Gonzalez Hospital

Figure 1. Shows the exterior facade of the hospital [23]

TABLE 1.

Information about Manuel Gia Gonzalez Hospital			
Project name	Manuel Gia Gonzalez Hospital	facade area	2500 m2
Owner	Ministry of Health of Mexico	Location	Mexico City, Mexico
Architect	Elegant Embellishments	completed in	2013

Figure 2. Shows interface details [6]

Mexico City is known for its high population density and elevated traffic levels, leading to high carbon emissions. As a result, pollution levels and vehicular emissions have exceeded internationally allowed limits, prompting the United Nations to declare it the most polluted city in the world since 1992. Therefore, the architect of the city's hospital sought to make the building not only beneficial to the community but also to the surrounding environment.

The focus was not limited to the hospital's impact on the indoor environment alone.[24]

This facade extends along Avenida San Fernando, a major and congested thoroughfare in the city. It is an exceptionally suitable location for installing facades that contribute to air purification, equivalent to purifying the pollution generated by 1000 cars daily.

Figure 3. Demonstrates how to install interface modules [6]

The facade spans an area of 2,500 square meters and is constructed using a semi-crystalline grid of units (ProSolve 370e), three-dimensional units composed of a lightweight, fire-resistant ABS plastic shell. It is equipped with photocatalytic pollution removal technology. This facade is coated with ultrafine titanium dioxide that reacts with air pollutants in urban areas when exposed to ambient ultraviolet radiation. It breaks down these pollutants into less harmful compounds, such as water and carbon dioxide.[25]

The facade is coated with a thin layer of titanium dioxide (TiO_2). When integrated with sunlight, TiO_2 breaks down pollutants in the air, such as nitrogen oxides and volatile organic compounds, converting them into harmless amounts of water and carbon dioxide. The coating works to reduce pollutants.[7]

12.2. Lev Ulus Hospital

Figure 4. Shows the main interface of Lev Ulus Hospital (Source: Zoom 2012)

Table 2.

Information about Liv Ulus Hospital			
Project name	Lev Ulus Hospital	facade area	30000 m2[26]
Owner	MLP CARE	Location	Istanbul city, Türkiye
Architect	Zoom Office[27]	completed in	2013

Figure 5. Explains the X-ray room at Liv Hospital (Source: Zoom 2012)

Figure 6. Demonstrates the use of antibacterial acrylic fixed furniture to reduce transmission of infection (Source: Zoom 2012)

The LIV ULUS Hospital in Istanbul, Turkey, has been designed as a prominent medical facility for the treatment of heart diseases, tumors, orthopedic surgery, and general surgery. The hospital consists of 154 beds and 8 operating rooms, with a total area of 30,000 square meters.

The hospital is designed based on the principle of the body's self-healing, benefiting from the analysis of how living cells achieve healing and combat foreign bodies. To enhance this concept, nanotechnology techniques have been used in interior finishes to provide a healthy environment for patients, staff, and visitors.

Materials treated with nanotechnology have been used in several aspects of the hospital, such as:

Curtains in patient rooms: Featuring antibacterial and fire-resistant properties.

Bathroom finishing materials: Characterized by antibacterial and self-cleaning properties.

Ceramic flooring: Contains antibacterial materials.

Wallpaper and paints: Include antibacterial properties, ease of cleaning, and recyclability.

Window glass: Utilizes nanotechnology for lighting and thermal insulation.

These technologies have been implemented throughout the hospital, from curtains to fixed furniture, to provide a cost-effective and environmentally friendly healthcare environment with a focus on sustainability.

The Applied Study will focus on greenhouse gases, particularly carbon dioxide (CO2), to understand the impact of electricity consumption in spaces. This focus stems from several reasons:

1. Rising Average Temperature:

Scientists have observed an increase in the average temperature from 1880 to 1980 by approximately five degrees Celsius, attributed to the significant spread of greenhouse gases.

2. Impact of Electricity Consumption:

The impact of electricity consumption on temperature rise is a major factor, significantly affecting the ozone layer. Among the harmful gases in this context is Freon, which spreads due to the use of air conditioning systems in buildings.

3. Role of the Atmosphere:

The atmosphere plays a role in trapping heat near the Earth's surface, but this trapping must be within specified limits. An increase in heat retention, preventing it from escaping into space, can lead to negative consequences.

4. Effect of Air Conditioning Systems Inside Buildings:

Electricity consumption in air conditioning systems inside buildings contributes to the spread of greenhouse gases. Additionally, this high electricity consumption is considered a constant source of microbes and bacteria, as air conditioning filters retain them and continue to release them into the environment.

13. Analysis of Chest Hospital in Kafr El-Sheikh

Owner	Ministry of Health
Executing Authority	National Organization for Military Production
Project Consultant	Al-Binyan Engineering Consultants

13.1. Components of the hospital:

- The hospital consists of a main building with 4 floors (ground floor + 3 repeated floors).
- Reception and clinics building with 2 floors (ground floor + first floor).

A table of the main building components

Floors	spaces	Floor area
Ground Floor	Direct Examination - Blood Chemistry – Radiology - Main Pharmacy - Microbiology Laboratory - Tuberculosis Cultivation - Manager's Office - Head Nurse - Quality and Safety Committees - Radiology Technical Office - Administrative Director - Agents' Office - Medical Information Center - Employee Affairs – Kitchen – Storage - Central Laundry	1180
First Floor	Tuberculosis Isolation (8 beds) - Pediatric Ward (8 beds) - 2 Male Wards (16 beds) - 2 Economy Class (4 beds) - Influenza Isolation (8 beds) - Sterilization Room – Endoscopy - Social Insurance Pharmacy - Pulmonary Endoscopy - 3 Changing Rooms for Personal Protective Equipment - Microbiology Lab	1180
Second Floor	Intensive Care Unit (6 beds) - 2 Intermediate Care Units (16 beds) - 2 Female Wards (16 beds) - 3 Economy Class (6 beds) - Mobile Radiography - 2 Furnished Storage Rooms - Internal Pharmacy - Dressing Room - 3 Changing Rooms for Personal Protective Equipment	1180
Third Floor	Men's Dormitory (2 Resident Doctor Residences - Nursing Residence - Radiology and Laboratory Technician Residence - Training Hall) Women's Dormitory (Resident Doctor Residence - 2 Nursing Residences - Workers' Residence - Kitchen - Waiting Room)	1180
		4720

A table of the components of the reception and clinics building

Floors	spaces	Floor area
Ground Floor	Reception - Men's Clinic - Women's Clinic - Pediatric Clinic - Isolation - Triage - Sorting - Medicine Storage - Tuberculosis Clinic	285
First Floor	Dental Clinic - Dental Radiology - Infection Control Office - Lung Clinic - Pharmacy - Warehouses - Medical Equipment Maintenance - Emergency Director's Office	285
		570

13.2. Applying the proposed standards to achieve environmental safety at Sadr Kafr El-Sheikh Hospital

Spaces	External clinics	Radiology departments	Analysis labs	Emergency departments
Finishing Requirements				
Glass				
Low thermal conductivity				
Does not cause heat loss				
Provides natural light without transferring heat				
Contains a thermal insulation layer that does not affect lighting				
Anti-condensation and fog				
Provides a clear view of the external environment	yes			
Noise insulating	Yes			
Fire-resistant			yes	yes
UV non-permeable				
Easy to clean			yes	
Self-cleaning	yes			
Insulation				
External wall insulation				
Lead-shielded radiation space insulation		yes		
Use materials that do not significantly increase wall thickness				
Lightweight, does not impose a load on the building				
Wall Finishing				
Does not emit harmful emissions				
Helps purify the air				
Non-bacterial				
Does not cause glare				
No need for chemical cleaners (easy to clean)				
Does not cause infection transmission			yes	
Does not cause sound reflection				
Floors				
Non-reflective to light				
Non-reflective to sound				
Does not emit chemical pollutants				
Does not cause infection transmission			yes	
Helps purify the air and kill bacteria				
Does not cause slipping and sliding				
Easy to clean	yes	yes	yes	yes
Indoor Furniture				
Self-cleaning, does not cause infection transmission				
Does not cause sound reflection				
Does not cause falling and injuries to users	yes	yes	yes	yes
Ventilation				
Quality of outdoor air	yes		yes	
Building block design to avoid wind vortices				
The external air source does not pass any pollution source	yes		yes	yes
Natural ventilation in labs and mechanical ventilation				
Use exterior paints that purify the air				
Ceilings				
Does not cause light reflection	yes	yes	yes	yes
Antibacterial				

Dirt and dust resistant				
Absorbs sound				
Self-cleaning				
Lighting				
Provide sufficient natural lighting for the space				
Openings should not be less than 0.1 of the space area	yes	yes	yes	yes

1. Objective of the Applied Study:

The applied study aims to investigate the use of nano-materials within the diagnostic spaces of Chest Hospital in Kafr El-Sheikh (outpatient clinics) as an example of diagnostic spaces.
Expected Environmental Goals with the Application of Nano Materials

1.1. Environmental Objectives

- Indoor air quality improvement.
- Thermal insulation enhancement.
- Acoustic insulation.
- Natural lighting improvement.

1.2. Expected Economic Goals

- Reduction in maintenance and usage costs.
- Increased life expectancy.
- High material quality.

1.3. Design Objectives

- Green architecture orientation (sustainable).
- Smart architecture orientation.
- Bioarchitecture orientation.

2. Program Factors to be Studied

- Carbon dioxide levels in the space.

3. Nano Materials Used on the Building

3.1. XPS Insulation in Exterior Walls

Nano Insulation Materials (NIM):
Nano-insulating materials (NIM) can be described as fundamentally homogeneous materials that exhibit high-performance thermal insulation properties. This is achieved through their nanostructure, either open or closed, by reducing the pore size to make the maximum pore size in the material smaller than the average free path of air.

3-2- Nano-treated glass

Glass is known to be one of the most popular and adaptable building materials in use today, in part due to the continuous improvement of solar and thermal performance, and one way to achieve this performance is through the use of passive low-e coatings and solar control.

4. Applied Study:

AN APPLIED INVESTIGATION WAS CONDUCTED ON ONE OF THE OUTPATIENT CLINIC SPACES AT SADAT KAFR EL-SHEIKH CHEST HOSPITAL, SERVING AS AN EXEMPLAR FOR DIAGNOSTIC AND TREATMENT SPACES WITHIN THE HOSPITAL. THE STUDY INVOLVED MEASURING THE LEVELS OF CARBON DIOXIDE, MONITORED CONTINUOUSLY OVER 24 HOURS PER DAY THROUGH THE YEAR.

VARIOUS ALTERNATIVES INVESTIGATED

1. Building Orientation: The building's orientation was altered in all four cardinal directions (west, north, east, and south). The impact of these changes on factors such as carbon dioxide levels, was thoroughly examined.
2. Nano-Glass: Nano-glass was employed, utilizing double-layered glass (6mm) with solar heat gain coefficient of 0.2 and heat loss coefficient of 1.55. The study explored the effects of its application under different orientations.
3. Thermal Insulation: XPS insulation, with a density of 35 kg/m³ and thermal conductivity of 0.03, was used for the external walls. The study assessed the impact of this insulation under varying orientations.
4. Nano-Glass with Insulation: The combined impact of nano-glass and XPS insulation was examined to gauge their synergistic effects.
5. Opening Ratios: Different opening ratios were implemented on the external walls to investigate their influence in conjunction with varying building orientations.

4.1. Base Case for the Building

(Walls 25 cm - 6 mm double reflective glass - openings (window 1 x 1.20), space height 3 m)

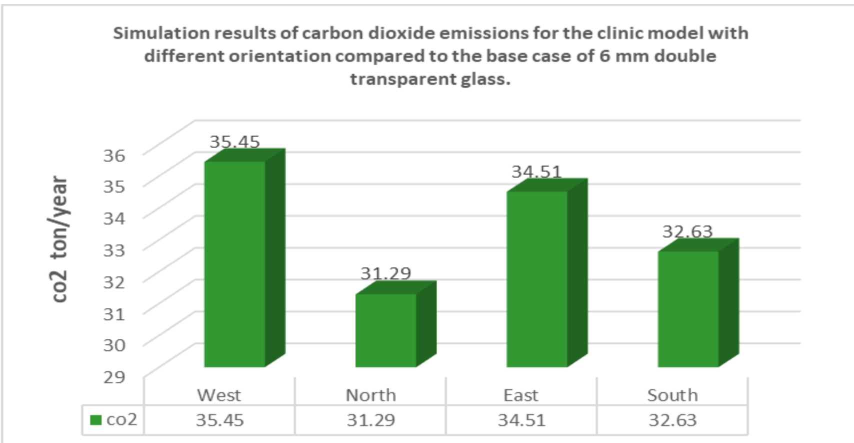

Figure 7. It shows the annual levels of carbon dioxide for the current situation according to the different directives
(Source: Researcher)

- In comparing the current building orientation, the optimal orientation for carbon dioxide emissions in the space was found to be facing north, with an average of 31.29 tons per square meter annually. This signifies a difference of 4.16 tons/m² compared to the current orientation of the building.

4.2. Use XPS thermal insulation for the walls

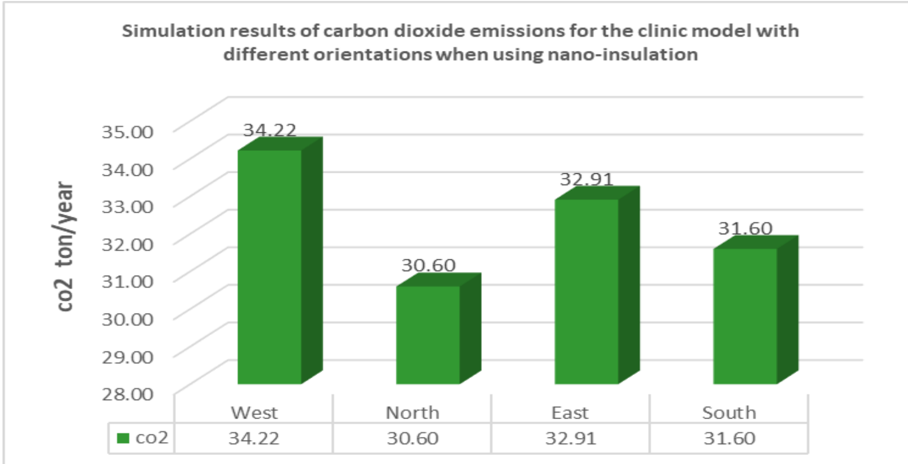

Figure 9. It shows the annual percentages of carbon dioxide when using insulation according to the different directions (Source: Researcher)

In comparing the impact of different orientations when utilizing XPS insulation, the optimal orientation for carbon dioxide emissions within the space was found to be facing north, with an average of 30.60 tons per square meter annually. This represents a difference of 3.62 tons/m2 compared to the current orientation of the building.

4.3. Using Nano glass instead of regular glass

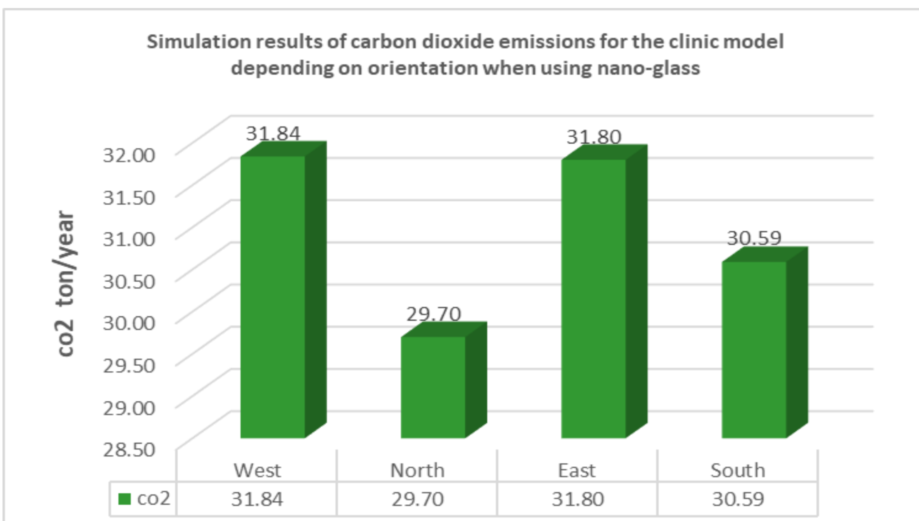

Figure 10. It shows the annual levels of carbon dioxide when using nano-glass depending on the orientation (Source: Researcher)

When comparing different orientations of the building with the use of nano glass, the optimal orientation for carbon dioxide emissions within the space was found to be facing north. This orientation resulted in an average of 29.70 tons per square meter annually, representing a decrease of 2.14 tons/m² compared to the current building orientation.

4-4- When using nano-glass with thermal insulation of walls

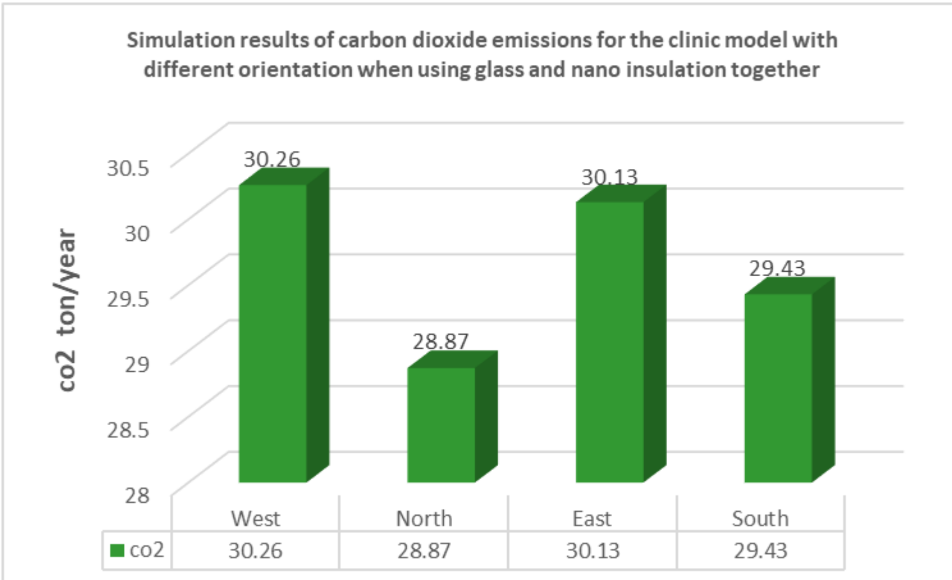

Figure 11. It shows the annual levels of carbon dioxide when using nano-glass with insulation depending on the orientation (Source: Researcher)

Comparing the difference in orientation when using nano-glass with insulation, the best orientation for the percentage of carbon dioxide in the space was to the north, with an average of 28.87 tons per square meter during the year, a difference of 1.39 tons/m2 from the current orientation of the building.

SIMULATION RESULTS

1- The application of Nano Insulation (XPS) in the external walls of a building results in a 3.5% annual reduction in carbon dioxide emissions within space, contributing to thermal efficiency and lowering the building's carbon footprint.

2- The use of Nano Glass in a building reduces carbon dioxide emissions within the space by 10% annually, contributing to lower heat retention and decreasing the building's carbon footprint.

3- Nano Glass provides diverse design alternatives, influencing the ratio of openings in the building. This flexibility aids designers in freely choosing the most suitable form for the building and allows for direct interaction with the external environment, promoting faster patient recovery.

4- The use of nano alternatives to reduce energy consumption and lower carbon dioxide emissions is influenced by the orientation of the building.

5- The application of nano paint on walls in diagnostic and treatment spaces, offering easy cleaning, reduces the need for cleaning agents, thereby decreasing the spread of air pollutants generated by chemical cleaners.

CONCLUSIONS

Some Recommendations for Utilizing Nanotechnology to Achieve Environmental Safety

1. Ceiling

Use nano-treated aluminum panels for lightweight and durable ceiling structures.

Apply nano-coatings to the ceiling to improve surface resistance to stains and pollution.

2. Walls

Utilize nano-composite aluminum panels for external walls, with nano-insulation to enhance heat insulation and reduce weight.

Implement nano-technology in wall paint to improve its resistance to bacteria and germs.

3. Flooring

Use nano-materials for flooring, such as nano-concrete, known for high resistance and heat conduction properties.

Coat floors with nano-materials to aid air purification and reduce harmful emissions.

4. Windows

Apply nano-coating to glass windows to improve permeability, reduce pollution, and minimize the need for cleaning.

Nano-glass may contribute to providing natural light without excessive heat transfer.

5. Furniture

Incorporate nanomaterials in furniture manufacturing to minimize environmental impact and maintain air quality.

6. Lighting

Use nanotechnology in lighting sources to improve energy efficiency and reduce emissions.

7. Cleaning and Maintenance

Adopt nanomaterials in coatings that facilitate self-cleaning processes and reduce the need for chemical cleaners.

7. Attention to Invisible Effects on Human Safety:

Given the various invisible influences resulting from lifestyle advancements, such as different types of waves, magnetic fields, and fine pollutants from modern industries, there is a need to prioritize understanding and addressing these impacts on human safety.

8. Use of Anti-Fog Nano Paints:

Utilizing nano paints with anti-fog properties acts as an air filter inside spaces, consistently purifying indoor air for improved air quality.

9. Application of Nano-Coated Wood Furniture:

Incorporating wood treated with nano-coatings, featuring water-repellent effects similar to the lotus flower (lotus effect), in diagnostic and treatment furniture provides water resistance, dust repellency, and bacterial resistance. The invisible coating offers diverse design alternatives.

10. Continuous Maintenance with Nano Finishes:

Emphasizing the ongoing importance of maintenance when using nano finishing materials. While these materials extend maintenance intervals compared to traditional ones, they still require periodic upkeep. No material is entirely maintenance-free in the long term.

11. Enforcement of Green Hospital Codes:

Mandating all healthcare institutions, both public and private, to adhere to LEED requirements and the Green

Hospital Code, going beyond mere compliance with building codes specific to hospitals.

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