Assessment of Indoor Air Quality In Medical Facilities In Sudan

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Abstract:- This study is to evaluate the effect of air conditioning type on indoor air quality (IAQ) of healthcare facilities. The study was conducted by visiting several hospitals in Khartoum that use different type of air conditioning system. The tools used for data collection include questionnaire, personal communication as well as individual observation during the visiting. The result showed that the indoor air quality depends on the used air conditioning system. Hence good ventilation can be provided by choosing the appropriate air conditioning type.

Keywords:-. Indoor Air Quality; Medical facility; Ventilation; AC System

1. Introduction

Indoor air quality is a significant issue in health care. Airborne organisms common in the environment can pose a serious threat to a patient who is immune-compromised. A patient ill with a respiratory infection can spread dangerous microbes to other patients, staff, and visitors. Air pollution, both indoor and outdoor, is often considered the major cause of environmental health problems. Even few years back, the problems associated with outdoor air pollution have been well publicized due to the prominence of major pollutant sources (e.g., traffic, industrial, construction, combustion sources, etc.). However, in recent years, public concerns on indoor air quality (IAQ) have drawn a great deal of attention, as the isolation of indoor from outdoor environment become phenomenal with the widespread supply of tight-sealed buildings and the associated sick building syndrome (SBS) (Ehsanul et.al., 2012). The extent of exposure to indoor air pollutants can be regulated by an interaction between their indoor source strengths and the entrapped time in indoor environments. As people commonly stay in Indoors for up to 22 h per day, individuals are at a risk of adverse health effects through their exposure over a sustained period (Jonathan and Bernstein 2008). Indoor air pollutants are commonly emitted from several indoor compartments, e.g., waxes, paints, furnishing, clothing, building materials, and personal sources (McKone 1999). Indoor environment was hence favorable to emit a large quantity of air pollutants. If the heating, ventilation, and air conditioning (HVAC) system is not properly maintained, the combined effects of such factors can worsen the situation as the key sources of indoor pollution. Biological contamination can also proliferate in moist components of the system throughout the building (Bholah et al. 2000).

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The American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE) has realized the significance of properly designed ventilation systems to maintain clean conditions in Healthcare premises and the organization has prepared design guidance published in 2002 that provides detailed technical information on design to avoid nosocomial infections (Frank, 2003) The importance of indoor air quality is very critical in hospital and healthcare facilities. Hospital air conditioning assumes a more important role than just the promotion of comfort. In many cases proper air conditioning is a factor in patient therapy while in some instances it is the part of the treatment itself (Nirmal Ram, 2012). Hospitals in Sudan have different types of air conditioning system .individual air conditioning, ducted split unit, package unit and chiller system. However the relatively high cost of air conditioning has led to inadequate and improperly designed system with not enough care to factor in specific requirements for ventilation, filtration and cross contamination. Therefore this study conducted to evaluate the IAQ hospital with the different types of AC used.

2. Methodology

Sudan is the one of the largest country in Africa. It lies entirely within the tropics between 22° and 4°N, Khartoum is the capital and second largest city of the Republic of Sudan. Khartoum features a hot desert climate, with only the months of July and August seeing significant precipitation. Based on annual mean temperatures, Khartoum is one of the hottest major cities in the world. Temperatures may exceed 53 °C (127 °F) in mid-summer. Its average annual high temperature is 37.1 °C (99 °F), with six months of the year seeing an average monthly high temperature of at least 38 °C (100 °F). Furthermore, none of its monthly average high temperatures falls below 30 °C (86 °F). Temperatures cool off considerably during the night, with Khartoum's lowest average low temperatures of the year just above 15 °C (59 °F). The IAQ assessment was done by visiting three hospitals with different AC system in Khartoum these hospital are Dental Hospital, Emergency and Trauma Hospital and New Specialized Hospital. During these visits personal communication was conducted as well as questionnaire.

- Personal Communication

The personnel communication were conducted with the staff and employee in the hospitals

- Questionnaires

The questionnaires were designed to focus on personal background, comfort feeling, odor presence.

2.1 Dental Hospital:

The building was consisted of three floors with total area (800 m2). Ground floor contains clinics, central sterilization, x-ray, and dark room, file room, waiting area, offices. First floor contains clinics, waiting area, offices, plaster room, ceramic room, porcelain room, central lab, x-ray tech, dark room, plant room, sterilization, nurse rest room, technician's rest room. The second floor contains offices, VIP waiting, sterilization room, VIP clinics, cafeteria, meeting room, staff changing room.

2.1.1 Air Conditioning System:

The used air conditioning system in this building was split cassette unit two ways of 24000 Btu/hr used in large spaces, and 18000 Btu/hr used in small spaces as shown in Figure 1. The outdoor units are mounted on the roof ground as shown in Figure 2.

Figure 1: Split cassette indoor unit of dental hospital

Figure 2: split cassette outdoor unit mounted on the roof of dental hospital

2.1.2 Ventilation:

The building depend on the outdoor air which entering through the doors and windows (natural ventilation).

2.1.3 Exhaust System:

There is no exhaust system on the building except the window exhaust fan in the laboratories.

2.2 Emergency and Trauma Hospital:

This building consists of three floors (ground, first and second floor). The Ground floor contains laboratories, hot cases area, cold cases area, diagnosis area, clinics, X-ray, asthma room, cast room, pharmacy, dark room, trauma, septic theater, offices and apses room. The First floor contains an operation rooms, anesthesia store, sterilization rooms, patients ward, individual patient rooms, drugs store, nurses' station, rest room and kitchen. The Second floor contains an intensive care unit, patient rooms, offices, nurse's station and kitchen.

2.2.1 Used Air Conditioning System:

Many types of air conditioning systems have been used in this building:

- Split cassette unit used in the patient rooms, offices and kitchen.
- Ducted split unit used in laboratories.
- Package unit 100% fresh air used in operation rooms
- Primary package unit used in reception and waiting halls.

2.2.2 Ventilation:

The only way to refresh the indoor air in the building is by allowing the outdoor air to enter through doors and windows, a primary package unit used to supply a fresh air to the main waiting and reception hall of the hospital. The primary package unit maintained to provide the halls with 15% cooled tempered fresh air. The 100% fresh air package unit of (10 T.R) used for operation room.

2.2.3 Exhaust system:

Exhaust system in this building was according to zone needs i.e. in the operation rooms and intensive care units were ducted exhaust system, in laboratories, dark rooms and kitchen was normal window exhaust fans.

2.3 New Specialized Hospital

The hospital is currently under construction and it consists of seven floors (basement, ground, first, second, third, fourth and fifth floor). Basement floor contains a sterile area, microbiology (sterilization, washing, culture, rotain and special), hematology, molecular biology, kitchen, blood bank, waiting area. Ground floor contains a pharmacy, optics, emergency, laboratories, clinics, lithotripsy, cafeteria, mammography, X-ray, waiting area, audiology, computerized Tomography (CT-scan), Electroencephalogram (EEG), ultrasonic, Echo, Electrocardiogram (ECG), EQU, Magnetic Resonance imaging (MRI). First floor contains a pediatric, exam, dermatology, neurology, operation, ophthalmology, offices, Ear, Nose and Throat (ENT), clinics, cardialic, waiting area. Second, third and fourth floor Contain patient rooms, halls, clinics, offices and waiting area. Fifth floor contains an

operation rooms, waiting area, Intensive Care Unit (ICU), endoscopies, neonate, isolate.

2.3.1 Used Air Conditioning System:

The used air conditioning system is central type by using air cooled water chiller. There are 4 chillers of (650 ton) mounted on the roof of building.

2.3.2 Ventilation:

There are six air handling units mounted on the roof two Air handling units 100% fresh air with heat recovery for operation rooms, and four to provide tempered and cooled fresh air for other sectors of building.

2.3.2 Exhaust system:

The exhaust system of any floor was designed as a net of ducts subjected on bathrooms and cafeteria to collect all circulated air and throw it out by means of three master exhaust fans mounted on the roof of the building.

3. Result and discussion

3.1 Dental hospital:

When visiting the hospital it found that there are odors inside the building and that is due to the bad ventilation and exhaust system used. The split cassette doesn't provide fresh air, and the only way to supply the building by fresh air is natural ventilation (doors, windows), and for dental hospital the natural ventilation does not provide sufficient quantity of air because of the large space. More over the natural ventilation is not safe because the air entered from outdoor contain large amount of contamination e.g. (dust, bacteria…etc), and the air entered does not passes through filters, so it will affect the quality of indoor air. In the Dental hospital every two operation room s are separated by partition opened from the top, and shared one cassette unit, so this can lead to infection transmission and serious inflammation between patients.

3.2 Emergency and trauma hospital:

Two types of air conditioning systems used in emergency hospital.

- Ducted Split Unit system
- Package unit system.

Ducted Split Unit with cooling capacity of (12.4kw -12.7kw) is used in laboratories, waiting areas and patient rooms.

Figure 3: Ducted Split Outdoor unit on the roof of emergency hospital

The package unit provides 15% of the fresh air in the waiting areas and reception, which is not enough with respect to the large number of people in these areas. 100% packaged fresh air is supplied to the operation rooms, and 100% exhaust air, which maintain high quality of air within the operation room.

Figure 4: package unit and exhaust duct on the roof of Emergency hospital

It is observed that the flow of air within the operation room in emergency hospital is turbulent because the exhaust open is designed on the top of the room wall, which means there is mixing of supply air with return air.

3.3 New Specialized Hospital

Central air conditioning system by air cooled chiller is used in this hospital; the cooling capacity is about 650 T.R. When visiting the hospital it is found that there are many supply diffuser on the false ceiling to provide tempered and cooled fresh air and that will lead to appropriate ventilation. There are no odors inside the building. The ventilation provided in this hospital by using a primary air handling unit which provides a tempered cooled fresh air to the far terminal and to the crowded areas e.g. (lobbies, reception, waiting areas…etc). 100% fresh air AHU and 100% exhaust air systems used in the operation rooms, that system grantee clean areas with good indoor air quality. 100% fresh air AHU used in the operation rooms with HEPA filter and the

flow of air inside the operation rooms is laminar in order to protect the patient and the medical staff. The laminar flow ventilation system was developed to provide a method of controlling the transport of air contamination by introducing the supply air into the operating room at low uniform velocities promoting a stable downward flow of air. As shown in the Figure 5.

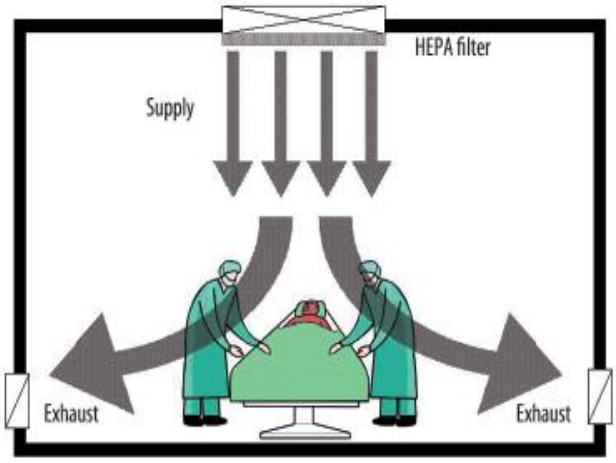

Figure 5: laminar flow in surgical operation room

To keep the room clean with no contamination enters; the exhaust air was designed to be less than the supplied by 10% - 15% and that maintain appositive pressure. It is obvious that the system used in the new specialized hospital can provide good ventilation and maintain pressure relationships between spaces.

Figure 6: Air Cooled Chiller on the roof of the new specialized hospital

4. Conclusion:

This study concern with evaluating Indoor Air Quality (IAQ) in health facilities in Sudan. Then assess the used air conditioning system in these hospitals. From this study it is concluded that: The hospital Air Conditioning system plays an important rule and has a great factor in IAQ. Individual unit such as window type and split unit does not provide an appropriate ventilation in critical areas of hospitals. Package unit can provide a certain amount of fresh air. Chiller system can provide full fresh air, so it is the most suitable system to be used. Comparing the used systems in Sudan hospitals with the standard system it is found that the hospitals do not confirm the standard system, except in some new designed hospitals which confirm most of the standards.

5. Recommendation:

Hence indoor air quality in health facilities is very important, and the air conditioning system has a great influence on it, following recommendation is suggested

1- The health care facilities in Sudan should follow the International Standard in selecting the air conditioning system.
2- There should be an official authority that set regulations to control the HVAC design in accordance with the international standards.
3- The HVAC designer engineer should be aware with the international standard for health care facilities.

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