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Research Article

INDOOR AIR QUALITY (IAQ) IN THE UAE RESEARCH IN ENVIRONMENTAL HEALTH AND SAFETY

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ABSTRACT

Indoor Air Quality (IAQ) has been one of the most important aspects that environmentalists consider. Since UAE residents spend 80%-95% of their time indoors to escape high temperatures. Individuals should pay attention to their indoor air quality to prevent short-term or long-term health effects that can be caused with single or multiple exposures. Measuring the air pollution and monitoring the dust, carbon monoxide and carbon dioxide found in Abu Dhabi, Dubai and RAK malls by utilizing TSI Indoor Air Quality Instruments, and dust monitor. The various locations have been selected such as (toilet, food court, hypermarket and gym). Surprisingly, the highest count of carbon dioxide was 2880 and above which found in the toilet zone. Furthermore, the dust was also found in the toilet which mean the worst zone was bathroom from the samples are that we selected.

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INTRODUCTION

Since the discovery of the oil resources in the United Arab Emirates (UAE) it has allowed its citizens to advance and elevate within the past 50 years from a desert environment to a well flourished lifestyle with modernized technologies and infrastructure making its per-capita gross domestic product ranked the 6th in the world (International Monetary Fund 2012) (Ibrahim12-24)

With this expeditious economic growth has raised great-scales infrastructure development, inclusive with new transportation networks, and cities. Due to these monumental changes the United Arab Emirate's population increased rapidly from 2 million to 9.4 million in less than 20years (1997 to 2013). Out of 9.4 million only 15%-20% are local of nationality and the rest are immigrants from Pakistan, Jordan, India, Egypt, Palestine and many more.

Another substantial change that has taken place in the United Arab Emirates(UAE) has been the alteration from naturally ventilated huts and nomadic tents to securely sealed air-

conditioned villas and apartments to ease the intense temperatures of the UAE. These newly built structures lead to hidden exposures to pollutants that accumulated in these buildings. Whilst these extreme changes to the economy and social aspects resulting from the progress of public health, concerns regarding the rapid modernization may have caused environmental concerns (Ibrahim12-24) Indoor Air Quality (IAQ) is the term used to address air quality in buildings and structures and surrounding areas. Most importantly that it has a significant effect on the comfort and health of building occupants ("Identifying Problems in the Indoor Environments [Indoor Air Quality (IAQ) |US EPA]"). Knowing what are the common indoor pollutants to reduce and control can help minimize health concerns. Health concerns resulting from indoor air pollutants can be immediate or can show many years later.

The effects that are caused shortly after a single exposure or repeated exposures to indoor air pollutants are often treatable and short-term. These health effects include irritation of the nose, eyes, throat, nausea, headaches, dizziness and fatigue.

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Such instant effects are not to be worried about because most of the time just eliminating or avoiding exposure to the indoor air pollutant that caused the health effects, if it can be identified could treat them.

Health effects differ from an individual to another due to each person's sensitivity as well as preexisting medical conditions. Other more serious long-term health concerns can be caused by indoor air pollution such as respiratory diseases, heart diseases and cancer. These long term health effects can make the individual very debilitated or can even caused eath. Indoor air quality has to be taken care of seriously even before symptoms are noticeable to provide a healthy lifestyle for individuals especially for those living in the UAE. Residents of the UAE spend 80% to 95% of their time indoors to escape high temperatures ("Study of Indoor Air Quality Risks in United Arab Emirates"). Thus, in this research we utilized two types of machines that aid us to determine the indoor air quality in the Malls. Our designated areas were Abu Dhabi, Dubai and RAK malls. We have been a group of three undergraduate students that covered all these three cities in UAE.

Justification

Breathing good quality indoor air is very critical for good health. UAE residents spend most of their time in doors whether in their homes, offices and other buildings to escape high temperatures. Poor indoor air quality could cause short-term or long-term health effects.

Table 1 Indoor air pollutants, their sources and riskson humans under short-term or long-term exposures

| Indoor air pollutants Sources Risks | Indoor air pollutants Sources Risks | Indoor air pollutants Sources Risks |
|-------------------------------------|---|---|
| Carbon Monoxide (CO) | Carbon Monoxide (CO) Produced by incomplete combustion of fossil fuel. | Stops your body from using the oxygen it needs to work normally. (Headaches, dizziness, nausea, confusion, fast heart rate.) |
| Radon | It is found everywhere in low levels. It is made naturally as the uranium in the earth breaks down. | Increases your risk of getting lung cancer. |
| Nitrogen Dioxide (NO2) | A common oxide of nitrogen. It is a toxic and corrosive gas. | Exposure to very high doses of NO2, such as at the site of a building fire, can lead to pulmonary edema (potentially fatal liquid build-up in the lungs) or lung injury. Moderate exposure can lead to acute or chronic bronchitis. Low-level exposure can impair lung function for people who are already at risk, such as asthmatics, people with chronic obstructive lung disease, and children. |
| Secondhand smoke | Incompletely burned tobacco products. | Eye, throat and nose irritation. In the long-run it can cause the same health effects as smoking, like wheezing, pneumonia, bronchitis, lung cancer. |
| Lead particles | House paint | Brain, nervous system, kidneys, and red blood cells damage. If children are exposed they can develop short attention span, behavioral problems, lower IQ levels, and delayed growth. |
| Asbestos | Used for a group of minerals found naturally all over the world. | In the long-term, exposure to asbestos can lead to various lung disorders, including lung cancer, and asbestosis (an inflammatory condition of the lungs that causes coughing, trouble breathing, and permanent lung damage.) |
| Mold | Are types of fungi that grow indoors and outdoors. | Mold can trigger an allergic reaction in some people. Symptoms can include nasal stuffiness, eye or throat irritation, swelling, coughing or wheezing, headaches or skin irritation. |
| VOCs | Perfumes, hairsprays, furniture polish, cleaning solvents. | Eye, nose, and throat irritation; headaches, loss of coordination, nausea, and damage to the liver, kidney, and central nervous system |
| Formaldehyde | Particle Board, interior grade plywood, furniture. | coughing, wheezing, chest pains, and bronchitis |
| Pesticides | Insecticides, disinfectants, consumer products, dust from outside. | Cancer, inability to breathe, weakness of muscles, apaxia and neurological problems |

Objectives

The science of indoor air quality is complex and rarely studied, yet it affects our daily lives on large scales due to the long hours spent indoors. This research will look into the different sizes and concentrations of indoor quality in the various areas from different mall in the UAE

LITERATURE REVIEW

Indoor air quality and its importance

Indoor air quality serves great importance for an individuals well-being since most of their time is spent indoors, specially in the United Arab Emirates (UAE). Due to intense temperatures through out the seasons, however, in summer reaching 45°C with humidity of 90% ("Dubai July Weather 2016 - Accuweather Forecast For Dubai United Arab Emirates") making it the hottest season. IAQ is considered one of the most basic elements for human's livelihood. Human health can be effected severely because of the long exposure time to indoor air pollutants.

Correspondingly, that humans spend 80% to 95% of their time indoors it is arduous to avoid indoor air pollution. Indoor air pollution can result from indoor sources as well as outdoor air sources such as computers, scanners, furniture, pets, HVAC systems all pose a higher health risk due to exposure time and concentration compared to outdoor air pollution. Indoor air pollution is a well-known issue to human health, although new researches indicate that the smallest particles in the air are the most dangerous.

Most dangerous size of Particulate matter

The focus to provide a healthy and productive indoor environment is to filter particles that are 1 µm (micrometer) or smaller in diameter.

This can also be referred to as PM1. PM1 can easily be inhaled by our respiratory system because there is no protection against these very small particles making it impossible for us to block PM1 or smaller particles. After these particles are inhaled they are then moved deep into our lungs and continue out our blood stream causing deadly diseases such as heart attacks and lung cancer.

Also, it has been recently stated that the small particles have an influence of Alzheimer's disease (AD) (Moulton and Yang 1-9). Air pollution is responsible for 4.3 million premature deaths around the world each year. Air pollution is the 4th highest risk factor for deaths globally and by far the leading environmental risk factor for disease. WHO ("Household Air Pollution and Health") has also mentioned through research that particles from diesel fuel combustion is carcinogenic.

Air pollutants that are considered to be the most harmful and are the reason behind increased risks of cardiovascular diseases are fine particles in the air measuring between 0.25 to 0.5 microns in diameter. Indoor air quality is of great importance and should be taken into consideration before symptoms start showing to avoid short-term and long-term health problems. Table 1 below discusses some indoor air pollutants and their sources as well as the risks they pose on humans under short-term or long-term exposures (Pollutants and Baker).

What happens inside our body

Particles that are 0.1µm - 1µm are usually the most dangerous. Because they have the tendency to reach our outer most areas of our respiratory system and then into our blood stream. Particles that can be trapped within the lungs and form deposits depend on their size as well as whether they can pass through our airway chambers.

4.3 million premature deaths a year occur from illness determinable from household air pollution produced by inefficient use of solid fuels (2012 data) for cooking. Among these deaths: ("Household Air Pollution and Health")

- 12% are due to pneumonia
- 34% from stroke
- 26% from ischemic heart disease
- 22% from chronic obstructive pulmonary disease (COPD), and
- 6% from lung cancer.

METHODOLOGY

This research's topic was about Indoor air quality measurement in three phases that include three different locations in the UAE. 1st phase was conducted at Abu Dhabi Malls, which covered three malls; Mazyed mall, Dalma mall and Yas mall). The places that have been tested are coffee shop, market and toilet. These places mentioned are the most visited places on malls. The monitoring and test of the Indoor Air Quality were through two machines; one of them is the Nephelometer which monitors the dust in the Air, while the other machine is called the IAQ which stands for (Indoor Air Quality) and it gives us the carbon monoxide, carbon dioxide, and relative humidity of the Air. We began with Mazyad mall because it was the near place to our university. Second place we selected in Abu Dhabi city was Dalma mall then we finished this the first phase with Yas mall. The list and charts attached identified the different between those three malls based on the size and crowded of people. For example we found that carbon dioxide in Dalma mall from coffee shop is more than Mazyed mall and that because of the size of the mall and percentage of people in this zone.



Figure 1 TSI and dust monitor



Figure 2 AD Location 1- Mazyed Mall, musaffah, Abu Dhabi



Figure 3 AD Location 2- Dalma mall, musaffah, Abu Dhabi

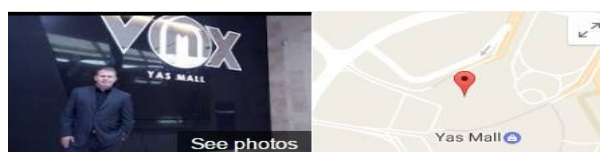


Figure 4 AD Location 3- Yas mall, Yas Island, Abu Dhabi

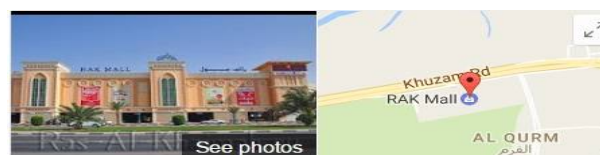


Figure 5 RAK Location 1- RAK Mall

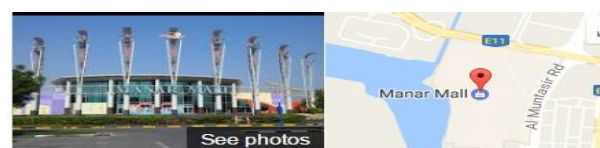


Figure 6 RAK Location 2- Manar Mall



Figure 7 RAK Location 3- Al Na'eem Mall



Figure 8 Dubai Location 1- Emirates Mall, Al Barsha



Figure 9 Dubai Location 2-Dubai Mall, Downtown

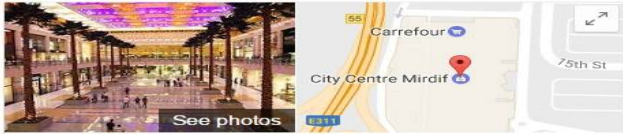


Figure 10 Dubai Location 3-MCC, Alwarqa

RESULTS AND DISCUSSION

The first phase of this research was conducted in Abu Dhabi (AD). Abu Dhabi is the federal capital of the United Arab Emirates and the largest of the seven emirates with a population of 2.784 million (Abu Dhabi Government, 2017). The results in AD locations were as follows:

Mazed Mall CO level in the air was 0.1 ppm which is below the standard (0.9) which is considered a safe level.

CO₂ level was 1115 ppm as an average which is higher than the standard (800ppm) and this is due to the high population in this location.

3rd, dust level in the same spot was 65 ug/m³ which is considered a safe level as it's lower than the standard (150 ug/m³).

Delma mall was the second place to study the indoor air quality, with 0.1 ppm CO level in the air which is below the standard (0.9) and considered a safe level.

CO₂ level was 1398 ppm as an average which is higher than the standard (800ppm) and this is also explained by the high population and poor ventilation in this location. 3rd, dust level in the same spot was 88 ug/m³ which is considered a safe level as it's lower than the standard (150 ug/m³).

The last mall in AD was Yas mall. It's newest mall in AD with 0.1 ppm CO level in the air which is below the standard (0.9) and considered a safe level. CO₂ level was 2164 ppm as an average which is higher than the standard (800ppm) and this is also explained by the high population in this location. 3rd, dust level in the same spot was 72 ug/m³ which is considered a safe level as it's lower than the standard (150 ug/m³).

The second phase was in RAK. With over 7,000 years of fascinating history and culture, Ras Al Khaimah is the perfect getaway from everyday life. Offering magnificent landscapes, breath taking coastlines and rich, terracotta desert planes, the emirate has firmly established itself as the UAE's most authentic destination in the Middle East (Authority). The sample that we choose from RAK malls were following:

RAK Mall consolidates the best in retail with fine feasting and stimulation for the whole family. With nearby and universal form brands, adornments and embellishments stores, beautifying agents outlets, electronic stores and so on. In this mall we also selected three different zones such as bathroom, First, I have got many ready of the CO level in the air and 0.6 ppm are the average and some of the ready was 0 ppm. So, 0.6 ppm it's a normal level in the air and it concenter as safe level people can be in this area safely.

Second, CO₂ level in the same area was 565 ppm as an average which is concentrations typical of occupied indoor spaces with good air exchange.

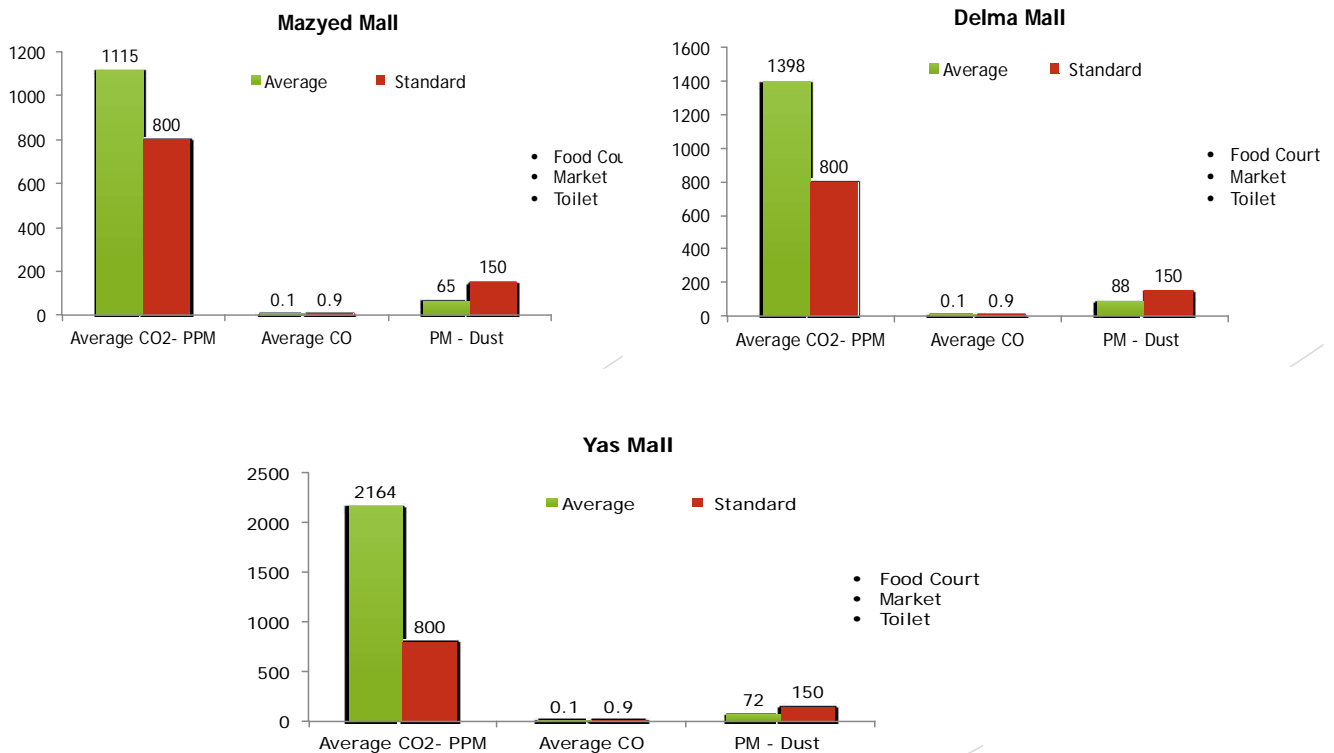


Figure 11 Results of AD Locations

3rd, dust level in the same spot was 44 ug/m³ which is pretty safe so far as soon as the mall has a good ventilation system so the air will keep exchange. Also the mall area is one of the best due to around the mall there is many green areas and sea and isn't that busy of cars over all. The second zone was food court, which was better than bathroom in the measurement. For example the carbon monoxide was 0.1 ppm as was 0.6 ppm in the toilet. However the dust was Similar to the bathroom. Furthermore, the last zones in this mall were hypermarket and as it obvious in the table below that this area were Similar to the other are that we tested.

Manar mall was the second place to measure the indoor quality at. This mall is famous shopping and leisure center in RAK. We began our measurement from bathroom. In this area we found that carbon monoxide was zero but the carbon was 751 ppm. Concerning the dust was higher than the previous mall as well but almost still at the normal level however that could be due to the renovation inside the mall as I mentioned before. In regard to the food court area we found that the indicators and measurement were similar to the bather room because of the mall contain only one floor so the air going to be almost the same everywhere on it. However, the final zone in this mall was hypermarket. We started by using the TSI for measuring and testing the carbon monoxide and carbon dioxide which was 0.1 ppm for CO and 730 ppm for CO₂ but the reading for dust level was 63 ug/m³

The last mall for RAK city was Al Naeem all. Its newest mall in the Ras Al Khaimah. As pervious mall we stated our testing from the toilet and we found that under control and normal because its new as building and opening so that means the mall has built with the newest air ventilation system, the mall located on busy area also that will affect the air quality inside the mall and the mall is quit huge it contain 3 floors and a wide area so that also might affect the air quality. In this area Co was zero but Co₂ was 743 ppm.

Then we utilized dust measurement machine and we found that the dust level in the point is 61 ug/m³. After that we moved to second point, which was the food court and we found that reading in this area similar to toilet area. Finally we went to hypermarket zone. In this area the reading was Co 0.1 ppm, Co₂ 719 ppm and dust 43 ug/m³. The air quality quite different in the hypermarket spot we have found 0.1 ppm CO reading in this spot, which wasn't in the last two spots. CO₂ and dust reading was less than the first two spots I might because of the hypermarket located in the ground floor also there's many entrances and exits on that area.

The last phase of our research and experiment was in Dubai. The city that has highest of population (2,822,452) in the UAE (Dubai online. 2017). There are more than ten malls that are consider as famous malls in the world and that due to development that features those malls. The famous malls in Dubai were chosen. Thus, Dubai mall, Emirate mall and Mirdif City center mall were taken as sample for this research. The tests were conducted on Friday because malls will be crowded with people during the weekend and it was one of our objectives to measure indoor air quality in the mall during busy day. The first mall we studied was emirate mall. We started our testing from toilet zone and we found that carbon monoxide was 0.0 ppm and the carbon dioxide was 586 ppm. However the dust level in this zone was 51 ug/m³. Then we moved to food court area and the time was lunchtime, which means the place was busy with the people. In this area we started with dust monitoring device and it was 92 ug/m³. After that we utilized the TSI for carbon monoxide that was 0.2 ppm and 556 ppm for carbon dioxide. The last zone in this mall was kids zone. We started with carbon dioxide reading, which was 563 ppm but the surprise was that carbon monoxide in this spot was 0.4 ppm, which mean it, is the highest reading that we found in this phase and this is because of a perfume shop around that burnt Oud in the shop. We continued our test with dust

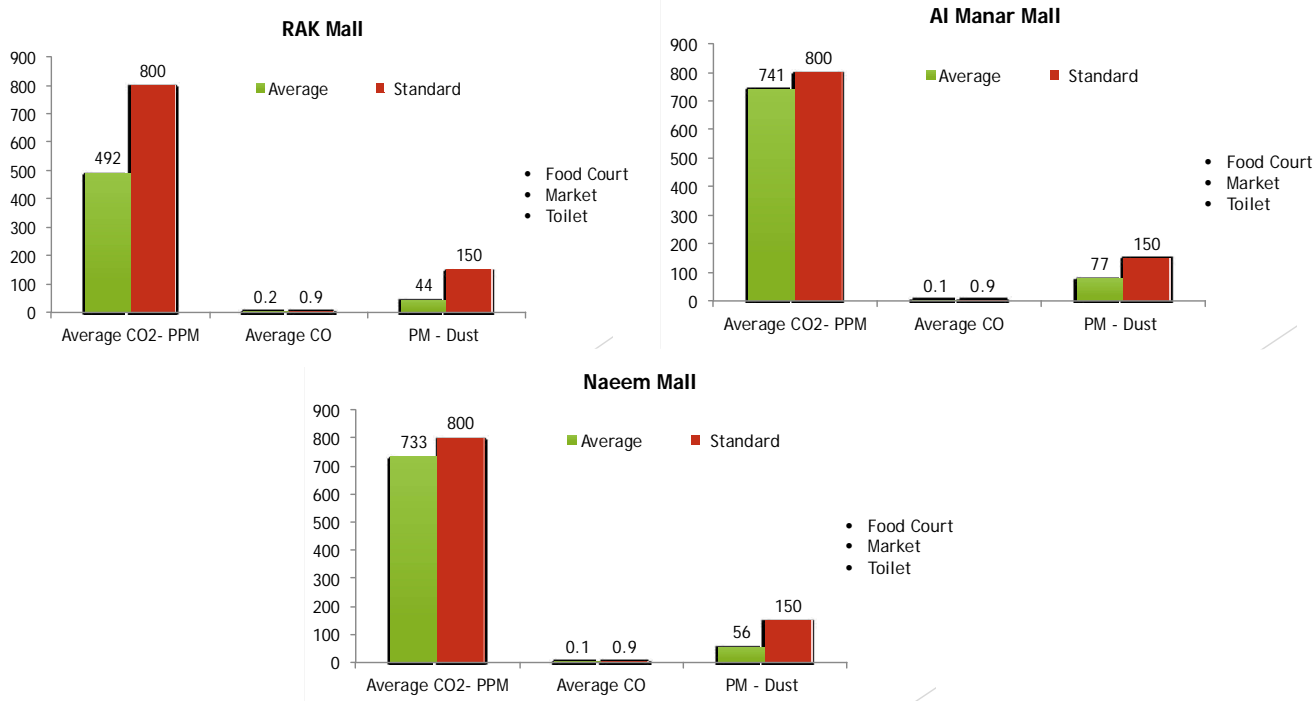


Figure 12 Results of RAK Locations

machine and it was normal 65 ug/m3. All the results were under the standard and that gave the indicators that the indoor Air quality in this mall is good.

At end of this research a comparison between the three emirates was done.

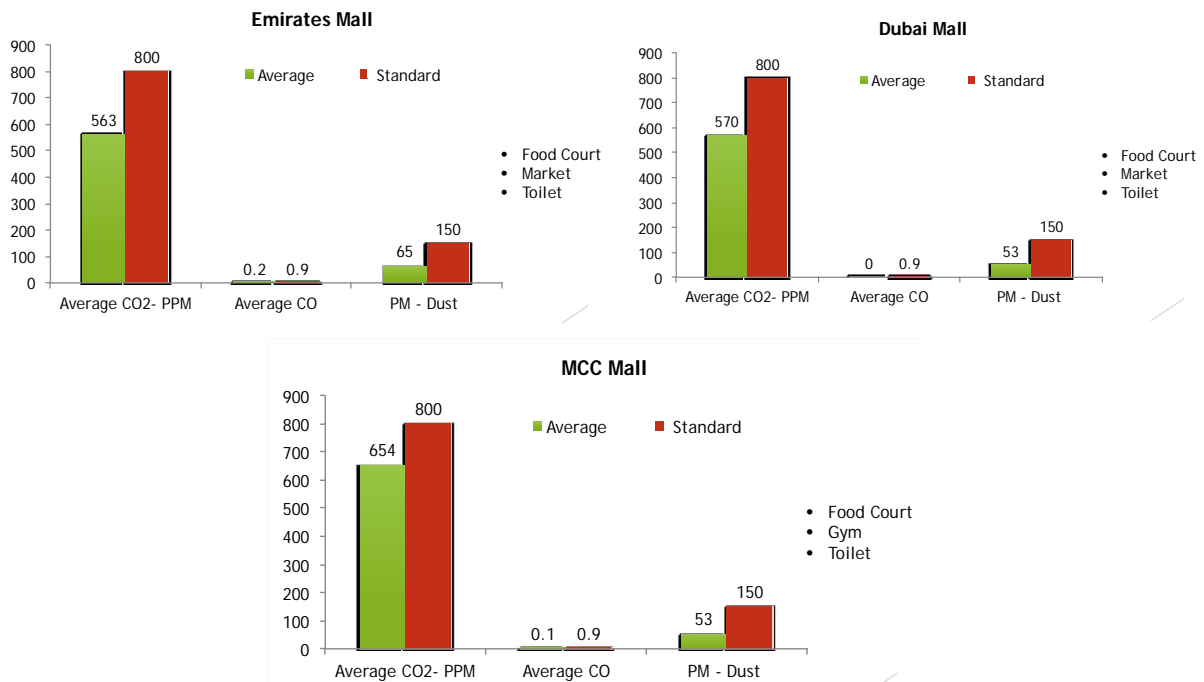


Figure 13 Results of RAK Locations

The second mall was Dubai mall. We started with food court area and we found that level was 0.1 for Co, 566 ppm for Co₂ and 54 ug/m3 for dust level. Then we moved faster to the second spot that was toilet that located in ground floor to save the time. The reading in this zone was similar to food court zone. The last zone for this mall was hypermarket. We took our reading as pervious area and we found that dust level is 53 ug/m3, Co 0.0 ppm and Co₂ 576 ppm.

The last step and area in our research in Dubai was Murdif City Center mall which is the newest mall in Dubai and it is located in the city center. In this area the plan and our strategic were different because we selected the zone that not covered in the previous malls and this area is Gym. The highest reading that we found in this spot is Co₂ 869 ppm, 0.1 ppm for Co and 38 ug/m3. The second zone was food court. The reading in this area was normal; 534 ppm for Co₂, 0.1 ppm for Co and 58 ug/m3 for dust level. The last zone was toilet that located near food court. In this spot the reading was 62 ug/m3 for dust, 0.1 ppm for Co and 533 ppm for Co₂.

The reading of the CO₂ we found that Abu Dhabi was the highest and higher than the standard, which was 800 PPM and Dubai, was lowest city in this experiment. Comparing CO, we found the all results were similar and under the standard. However the dust level for the three cities were under the standard.

The indoor Air quality in Dubai city was perfected and under control due to the new technologies and system that using in this city for keeping the place more health and safely to people.

CONCLUSION

As a conclusion Indoor air quality is essential for an individual's well – being due to the excessive amount of time spent indoors to escape the extreme temperatures of the UAE, causing long exposures to indoor air pollutants. Short-term or long-term exposures can produce adverse serious health effects. The composition and concentrations of the different components in indoor air vary widely and are influenced by human activities. Since it is not feasible to regulate all possible scenarios, prevention from possible health effects and protection of sensitive populations is best achieved by reducing exposure. As a consequence the SCHER recommends that all relevant sources that are known to contribute should be evaluated. Such sources include tobacco smoke, any open fires including candles, building materials, furniture, pets and pests, use of household products, as well as conditions that lead to the growth of moulds. Constructors, maintenance personnel and inhabitants should also be aware that appropriate humidity avoids annoyances and sufficient air exchange reduces accumulation of pollutants.

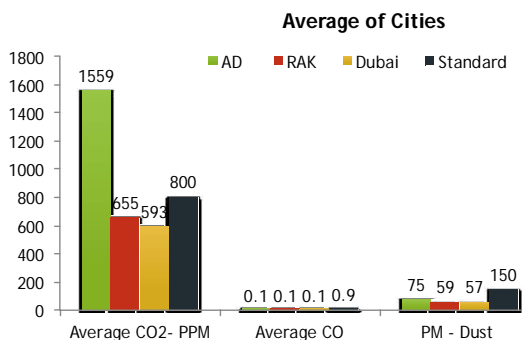


Figure 14 A Comparison between the three emirates

Recommendations

The recommendations after conducting this research are:

- Understanding Indoor Air Particulate Matter Composition and its importance to our well-being. Improve air quality by identifying the sources of pollution indoors and reducing their emissions. Install filters if space is provided, if there is no space to install filters you can use the mobile or Stationary air purifiers.
- Always use manual filtration by increasing the amount of outdoor air coming in doors.

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