جمهورية مصر العربية
وزارة التربية والتعليم

Capstone Portfolio

2018/2019

Group 12309 . Grade 12

Ethics and Creativity come first.

ALEX STEM SCHOOL

PCM

M.P.C.M

Monitoring & Purifying Carbon Monoxide

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Egypt grand challenges

Improving the use of alternative energies
Recycling garbage and waste for economic and environmental purposes
Urban congestion and its consequences
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Improving uses of arid areas
Managing and increasing the sources of clean water
Population growth and its consequences
Unemployment
Increasing the industrial base of Egypt.

Improving the use of alternative Energies

Fig (1)

Securing energy demand on continuous bases is a vital element for sustained development plans and Egypt as a country of limited fossil fuel resources as well as growing electric energy demand has given due considerations to diversify its energy portfolio by utilization of its renewable energy resources, mainly wind due to its economic potential and solar as proved by Egypt's wind and solar atlases. Supported by a sustained governmental commitment and a fruitful international cooperation a series of large-scale wind energy projects have been constructed, at the Gulf of Suez with a total capacity of 550 MW, at Zafarana and Hurghada areas. In the solar energy field, the first solar thermal power plant of 140 MW with a solar share of 20 MW is currently under construction and it is planned to be operated by the end of 2010. Recently, Egypt has adopted an ambitious plan to cover 20% of the generated electricity by renewable energy by 2020, including a 12% contribution from wind energy, translating more than 7000 MW grid-connected wind farms. Such plan gives a room enough to the private investment to play the major role in realizing this goal. Current study will focus on analyzing main challenges facing the target of reaching the 2020 goal of wind energy, such challenges as; The effect of loss of load probability in case of establishing these wind farms in three main areas; building sustainable financial schemes to implement nearly 700 MW yearly and cover the gap between the production cost and the selling price; finally building the requested infrastructure (i.e. substations, transmission cables, … etc.) for transferring the generated electricity.

Recycling wastes

Garbage in Egypt is a problem that seems to be unsolvable. The former government tried to solve it by recruiting foreign companies but didn't work. Now the revolution has aggravated the problem to such an extent that mountains of the garbage can be found everywhere.

Fig (2)

Strangely, these garbage mountains have become meals for the poor, which at least temporarily, sate their hunger.

The garbage scene is becoming more and more visible as trash is thrown everywhere in streets because no laws are being enforced in the post-revolution period. in many cities, residents have no allocated spots to throw garbage, nor do authorities have the means or resources to collect trash and take it away from cities.

Now Egypt started to fix this problem and one of the steps to solve this problem is building new recycling plants like the one in Port Said The plant, which cost around EGP 65 million, is ready to receive 550 tons of waste on a daily basis.

Urban Congestion

The Greater Cairo Metropolitan Area (GCMA), with more than 19 million inhabitants, is host to more than one-fifth of Egypt's population. The GCMA is also an important contributor to the Egyptian economy in terms of GDP and jobs. The population of the GCMA is expected to further increase to 24 million by 2027, and correspondingly its importance to the economy will also increase.

Traffic congestion is a serious problem in the GCMA with large and adverse effects on both the quality of life and the economy. In addition to the time wasted standing still in traffic, time that could be put to more productive uses, congestion results in unnecessary fuel consumption, causes additional wear and tear on vehicles, increases harmful emissions lowering air quality, increases the costs of transport for business, and makes the GCMA an unattractive location for businesses and industry.

In recognition of the seriousness of the problem of traffic congestion, and upon the request of Government, the World Bank funded an investigation into its magnitude, causes, and potential solutions in the GCMA. The objective of the study was intended to conduct a macro-level investigation of congestion in the GCMA: its magnitude, causes, associated economic costs, and potential solutions.

This report documents the results of the study. The results of this study should be of interest to policy-makers and practitioners in the GCMA, the Egyptian Government, other cities facing similar problems, and international financial institutions.

Public health issues

Health is a big challenge too because Egypt suffers a lot from health problems, a lot of patients in Egypt are infected with hepatitis (c), hospitals in Egypt are not ready to receive any cases, or find a cure, there is no scientific researches, bad habits like washing dishes and pins in the Nile, swimming in the dirty water, which spread the bilharzia disease.

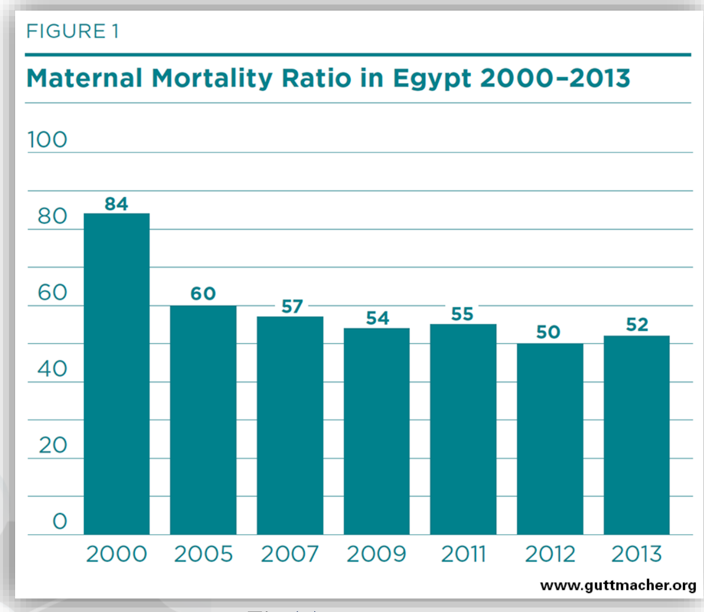


Fig (3)

Approximately 280 million injections were administered in Egypt during 2001, of which an estimated 8% (23 million) might have been unsafe.

That is because:

1) A lack of health-care workers with specific training or expertise in infection control.
2) Lack of formal infection control programs in most facilities.
3) Poor understanding among health-care workers regarding standard precautions for infection control.
4) Absent or inadequate equipment reprocessing, sterilization practices, and waste management.

Pollution

There are three main types of pollution which are: -

Air pollution

Air pollution is a mixture of solid particles and gases in the air. And it is caused by burning of fossil fuels, such as coal, oil, natural gas, and gasoline to produce electricity and power our vehicles.it has many effects on all living organisms and leads to many diseases.

Soil pollution

Soil, or land pollution, is contamination of the soil that prevents natural growth and balance in the land whether it is used for cultivation, habitation, or a wildlife preserve. The overpopulation is from the main reasons for the problem. Also, the lack of awareness in most of the people about the problem.

Water Pollution

It means one or more substances have built up in water to such an extent that they cause problems for animals or people. Oceans, lakes, rivers, and other inland waters can clean up a certain amount of pollution by dispersing it harmlessly.

Fig **(4)**

improving the use of arid areas

The arid area is a region which is characterized by a severe lack of available water to the extent of hindering or preventing the growth and development of plant and animal life. This problem happens due to the unbalance in the distribution of citizens all over Egypt and it leads to many other problems.

The following table shows some estimates of the arid areas in Egypt: -

Table (2). Population Percentages Distribution Over Agro-Ecological Zones in Egypt

Agro-Ecological Zones	Population Percentages (%)
Northern Coast	12.4
Nile Valley & Delta	85.2
Western Desert	0.2
Eastern Desert & inland Sinai	2.2

Table (3). Aridity Classification and Areal Distribution in Egypt

Aridity classification	Aridity index	Area (%)
Hyper arid	0.00	86%
Arid	0.00 – 20.0	13%
Semi arid	20.0 – 50.0	1%

Table (1)

Managing the resources of clean water

Egypt has only 20 cubic meters per person of internal renewable freshwater resources, and as a result, the country relies heavily on the Nile River for its main source of water. Egypt is facing an annual water deficit of around 7 billion cubic meters. In fact, United Nations is already warning that Egypt could run out of the water by the year 2025.

Egypt has been suffering from severe water scarcity in recent years. Some of the major factors playing havoc with water security in Egypt:

1. Uneven water distribution.
2. Inefficient irrigation techniques.
3. Water pollution.
4. Water efficiency.

We can improve the sources of clean water by improving alternative sources of water which are:

1. Using the underground water. 2. Harvesting water from rain

Fig (5)

Population growth

The exponential population growth is a big problem that faces Egypt, because a big percentage of Egyptian people have children and they don't think about their future, some people have children and make them work in a small age in order to cover the costs of bringing the children up so it leads to another problem which is the case of the child labor. Also, Egypt doesn't have the adequate resources to provide education, health care and the essential infrastructure to this large population, so the overpopulation leads to a lot of other problems like health care issues.

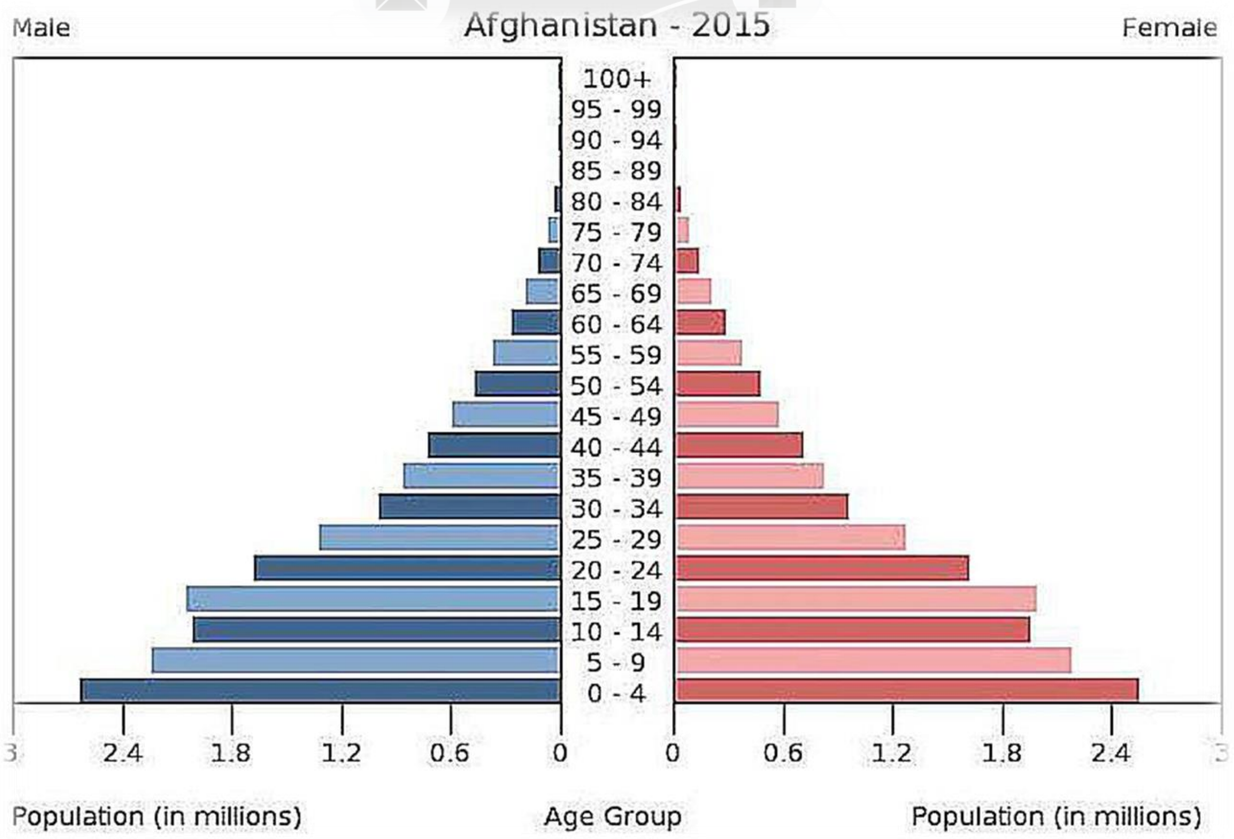


Fig **(6)**

Unemployment

Egypt is a lower middle-income country with a population of 84 million in 2012, While the population growth rate is declining (at 2.2%), Youth unemployment still a serious policy challenge in Egypt. Unemployment affects the young and the educated. According to recently announced statistics from Egypt's Central Agency for Public Mobilization and Statistics (CAPMAS), the unemployment rate among youth has reached 26 %.
The following figure shows unemployment rates among different years.

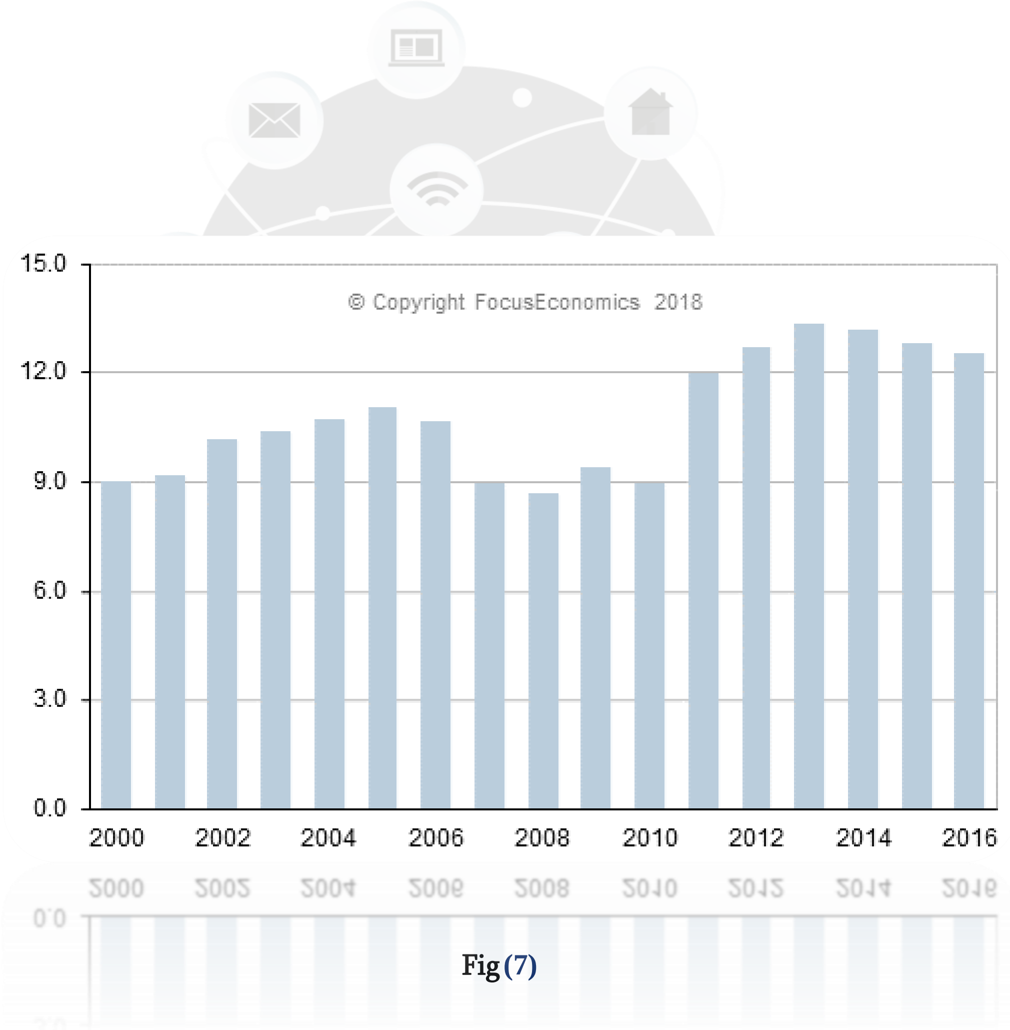


Fig (7)

Increasing the industrial base of Egypt

Future industrial policies in Egypt will be focused on enabling the industrial sector to be the engine of growth through the expansion of exports and job opportunities. The industrial sector in Egypt is a major contributor to economic growth, employment and export proceeds. Roughly accounting for 20 percent of GDP (excluding informal industrial activities), there are around 26,000 formally registered industrial establishments employing nearly 2.4 million workers and around 1.5 million workers in informal industrial establishments which represent around 20% of the labor force. In addition, manufactured exports account for nearly 3% of GDP.

In 2012 the industrial sector is best-positioned as a potential growth driver *because:*

• It has strong links with other important economic sectors such as agriculture and services;

• It offers high prospects for employment creation, especially in labor-intensive industries.

• It acts as a catalyst for technology transfer and attraction of FDI.

The Industrial Development is centered on three major axes:

- Achieving higher growth in industrial production through utilization of export development and FDI attraction.

- Effecting a leapfrog in industrial productivity through a carefully-designed set of policies and programs aiming at leveraging industrial competitiveness.
- Achieving a gradual shift in the industrial structure from resource-based and low-tech activities to medium- and high-tech industries.

Problem to be solved

The problem of air pollution in Egypt:

The air pollution in Egypt is a matter of a serious concern. The air quality in downtown Cairo is more than 10 to 100 times of acceptable world standards. Cairo has a very poor factor because of lack of rain and its layout of tall buildings and narrow streets, which create a bowl effect (bad ventilation and consequent trapping of pollutants). The main air pollution problem in Egypt is the particulate matter. The most notable sources of the dust and small particles are transportation, industry and open-air waste-burning. Another significant source is not the wind blown from arid areas around Egypt.

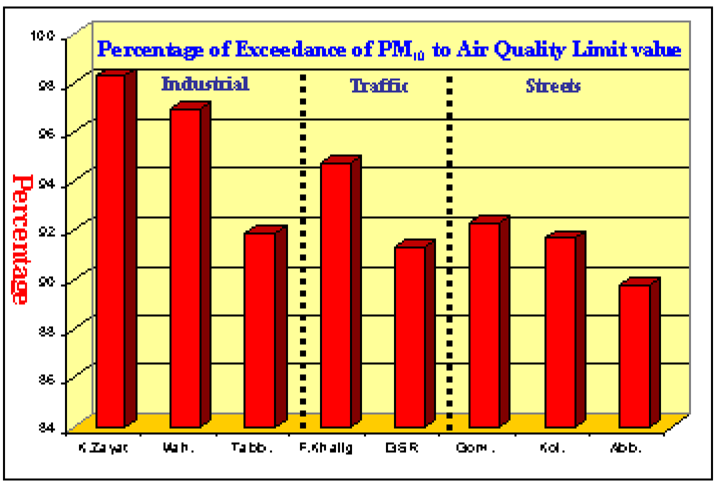


Fig (8)

The air in Egypt is very thick, gray and there is a haze over Cairo. Furthermore, other forms of air pollution are a carbon monoxide (CO) in streets, due to the excess amount of cars' exhaust and factories pollutants. The sky is gray rather than blue, which is very similar to the gray skies in Mexico City, London, and Beijing pollutants, of course, create a lot of respiratory diseases as the United States Environmental Protection Agency has published risk data which state that above the safe limit, the risk of developing serious respiratory diseases and cancer from inhaling particulates in the air (dust & soot, hydrocarbons, and heavy metal compounds) is: 2 people for every 1000.

Detailed climatological analysis of weekly mean carbon monoxide (CO) over the Nile Delta:

Since 1999 Cairo and the Nile delta region have suffered from air pollution episodes called the “black cloud” during the fall season. These have been attributed to either burning of agriculture waste or long-range transport of desert dust. Based on satellite data, monthly mean values of Moderate Resolution Imaging Spectroradiometer (MODIS) aerosol optical depth (AOD) at 550nm were examined for the 10 years 2000–2009. Significant monthly variability is observed with maxima in April or May (0.5) and October (0.45), and a minimum in December and January (0.2). Monthly mean 10 values of UV Aerosol Index (UVAI) retrieved by the Ozone Monitoring Instrument (OMI)for 4 years (2005–2008) exhibit the same AOD pattern. The carbonaceous aerosols during the black cloud periods are confined to the planetary boundary layer (PBL), while dust aerosols exist over a wider range of altitudes, as shown by Cloud-Aerosol Lidar

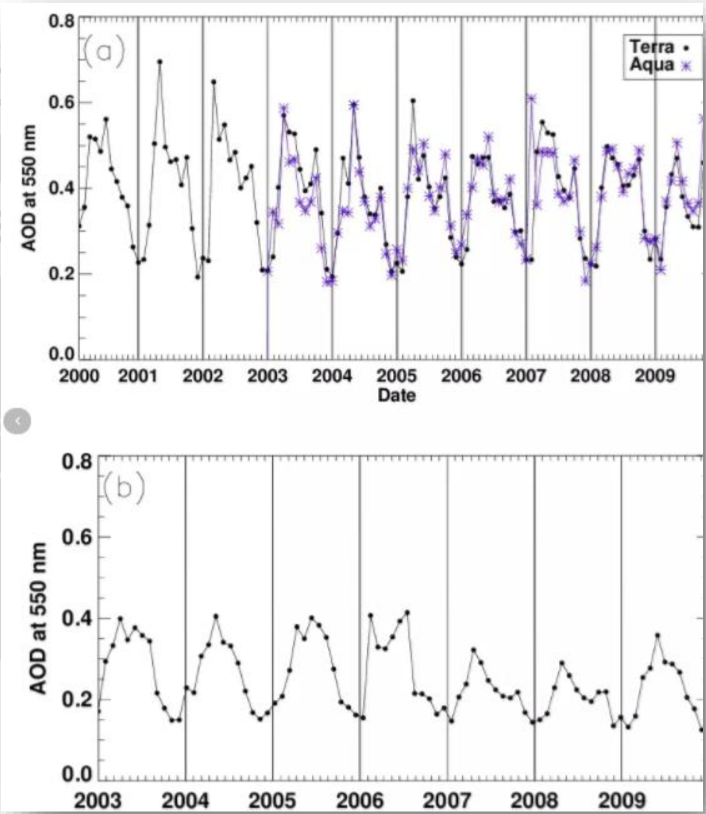
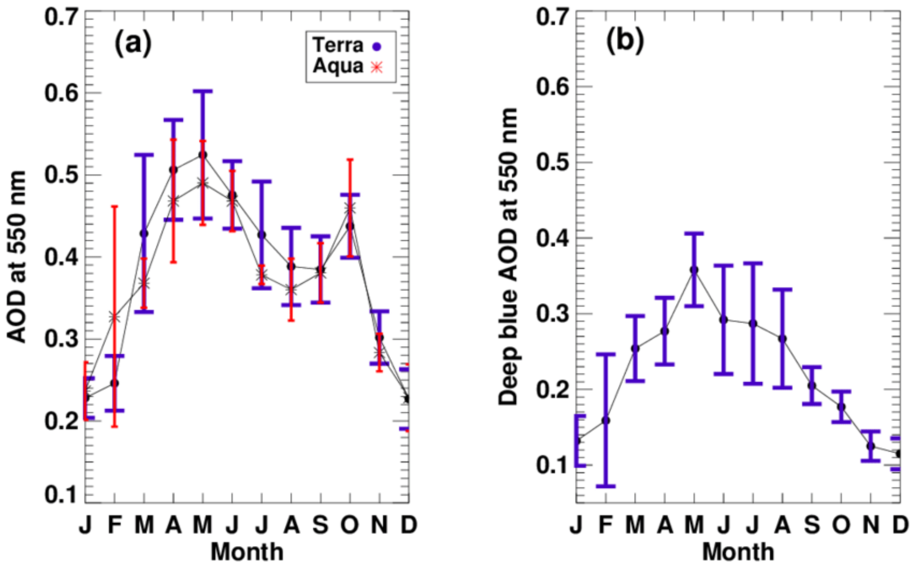


Fig **(9)**

and Infrared Pathfinder Satellite Observation (CALIPSO) aerosol profiles. The monthly climatology of Multi-angle Imaging Spectroradiometer (MISR) data show that the aerosols during the black cloud periods are spherical with a higher percentage of small and medium size particles, whereas the spring aerosols are mostly large non-spherical particles. All of the results show that the air quality in Cairo and the Nile delta region is subject to a complex mixture of air pollution types, especially in the fall season, when 20 biomasses burning contributes to a background of urban pollution and desert dust.

The characterization of aerosol optical and microphysical properties is crucial to the understanding of their effect on the Earth-atmosphere radiation budget and its climate. Thus, it is necessary that we continue to improve our characterization of aerosols, particularly in highly populated regions where the impact of aerosols on human health can be great. The Nile Delta, including Cairo, in Egypt is a region in need of better characterization of its atmospheric aerosol properties because of the area's high aerosol loading and lack of in situ observations. Figure 1 represents a base map of 5 Egypt including its main cities highlighting the high population over the Delta region. Greater Cairo with a population of 16 250 000 in 2006 (DWUA, 2009), is one of the most polluted cities in the world. Particulate pollution is a serious problem, since traffic and industries located within the city of Cairo or in the neighboring regions emit particles all year long. Cairo is also bounded by the Mokattam Hills that produce large concentrations of airborne sand during strong spring wind events. The chemical composition of bulk aerosols over 1.5–3 years at two urban sites in Cairo. Their analysis indicated very high levels of mineral dust (over 100 µgm–3) in winter and spring; and more than 50 µgm–3 in summer and autumn.



Fig(10)

There are also seasonal sources of particulates, one of which is natural dust storms (Barnaba et al.,2004), that occur mainly in the spring and are called “Khamsin”. Another seasonal air pollution episode that has been observed in the fall every year 20 since 1999 is locally known as the “black cloud”. The black cloud is a dark haze that envelops Greater Cairo and surrounding areas during the fall months for varying number of days. The impact of this haze is significant; it has potentially harmful effects on peoples’ health, especially for people with sensitive eyes and respiratory problems. Children’s lungs become very susceptible 25 to illness when inhaling such high aerosol loadings hence, long-term exposure to these hazes can lead to asthma (Fleishman, 2009). Cairo aerosols are reported to have significant impacts on the public health. Furthermore, the opaque particle cloud over Cairo and its neighboring regions may affect regional climate through the scattering or absorption of radiation (Haywood et al., 1999; Herman et al., 1997; Robaa, 2004). It may even influence the growth of plants in the Nile Delta by altering the amount of radiation that is available for photosynthesis.

Furthermore, high aerosol loads are likely to influence the water cycle by suppressing precipitations (Rosenfeld, 2000). Hence, the elevated levels of particulate matter over Cairo, particularly during the black cloud events, are a cause of concern. Several studies have been conducted to understand the main reasons for the increased pollution levels in Cairo using ground-based and satellite air quality data. However, the genesis of the fall episodes (the black cloud season) is still under discussion and needs more investigations like the present study. In order to acquire further synoptic information and visualization of the aerosol characteristics, it is useful to analyze satellite data as well, since these data provide horizontal and vertical covering with fairly high temporal resolution. Marey et al. (2010) utilized data from several satellite instruments to examine the most likely reasons for the black cloud formation over Cairo. They used Moderate Resolution Imaging Spectrometer (MODIS) and the Multi-angle Imaging Spectroradiometer (MISR) with meteorological data and trajectory analyses to determine the cause of these events. MODIS fire counts identify the aerosol source as the burning of agricultural waste after harvest season in the Nile Delta region. MISR data show that these fires create low altitude (<500 m) plumes of smoke that flow over Cairo in a few hours, as confirmed by Hybrid Single-Particle Lagrangian Integrated Trajectory (HYSPLIT) forward trajectory analyses. Favez et al. (2008) analyzed the chemical composition during fall (i.e. the time of the black cloud) of bulk aerosols over 1.5–3 years at two

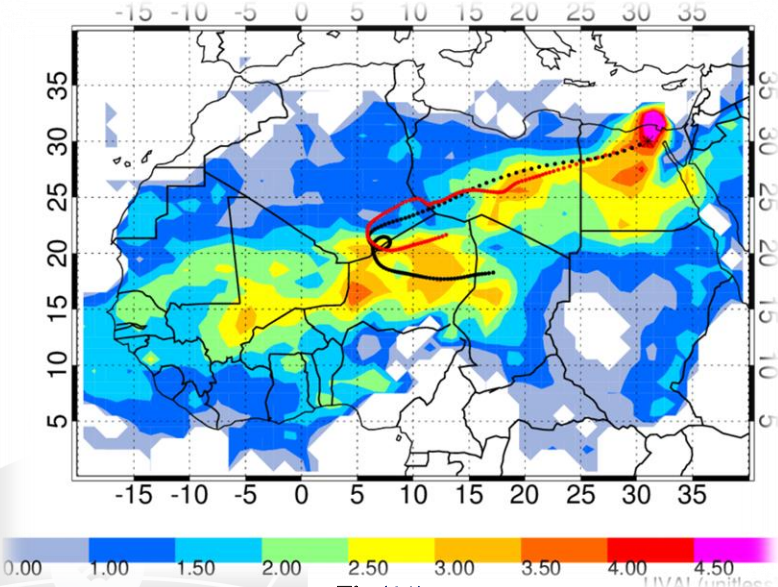


Fig (11)

urban sites in Cairo. These analyses indicated that emissions of rice straw burning account for 50% of the water-soluble organic carbon (WSOC). However, Prasad et al. (2010) suggest a different reason for the fall pollution (black cloud season). They showed that long range transport of dust at high altitude (2.5–6 km) from the Western Sahara and its deposition over the Nile Delta region is the major contributor to air pollution episodes at this season. Besides Zakey et al. (2004) mentioned the significant consequence of sand and dust particles emitted from the desert, and also from road-dust sand emitted from the road inside the towns itself in raising the aerosol optical levels in 5 spring and fall. From above it is clear that this region experiences a mixed aerosol loading scenarios hence, microphysical aerosol properties identification become highly needed.

This is a representation of satellite-based climatology of aerosol optical and microphysical properties over the Nile Delta, especially during the time of air pollution episodes either of natural or anthropogenic origins namely, April and October. To derive AOD climatology the MODIS Collection 5 monthly AOD550 product derived for 10 years from Terra data and for 7 years from Aqua data has been employed. Additionally, an OMI UVAI for 4 years (2005–2008) is used for the climatology of aerosol absorption. MISR AOD fractions at 558nm are used to study the climatology of microphysical properties 5 as size (small, medium and large) and shape (spherical and non-spherical). To further understand the results, the available AERONET aerosol data for 2004 and 2005 have been analyzed. The monthly variability of aerosol properties over the Nile Delta reveals that AOD550 peaks during April (0.5) and October (0.45), which is to be expected since these are the times when the dust and black cloud events occur in the region. However, the deep blue AOD550 mean values over the Western desert exhibit maxima only in the spring, with a mean value 0.35, that results from the enhanced emission of natural aerosols (dust storms). The difference between the spring AOD over the Nile Delta and the Western desert suggests additional aerosol loading in the Nile Delta due to anthropogenic sources. Moreover, the "background" AOD between the two observed maxima (April and October) is probably associated with urban-industrial pollution typical of larger cities (e.g. India cities, Cairo) in developing countries. The time series of Terra and Aqua MODIS AOD550 exhibits year to year variability over the Nile Delta and Western desert. The monthly AOD means are anticorrelated with the monthly precipitation. Consequently, precipitation is an important factor in atmospheric removal processes of aerosols in winter, and in the accumulation of particles during summer. However, in the spring and fall, the emission sources have more influence on regulating the aerosol levels, since the AOD anticorrelation to the precipitation at these seasons is poor. The monthly AOD500 from AERONET stations over Cairo agree with MODIS results, even though the observational methodology and time periods are not coincident. OMI monthly mean values of UVAI for 4 years (2005–2008) indicate that, the absorbing aerosols exist all year

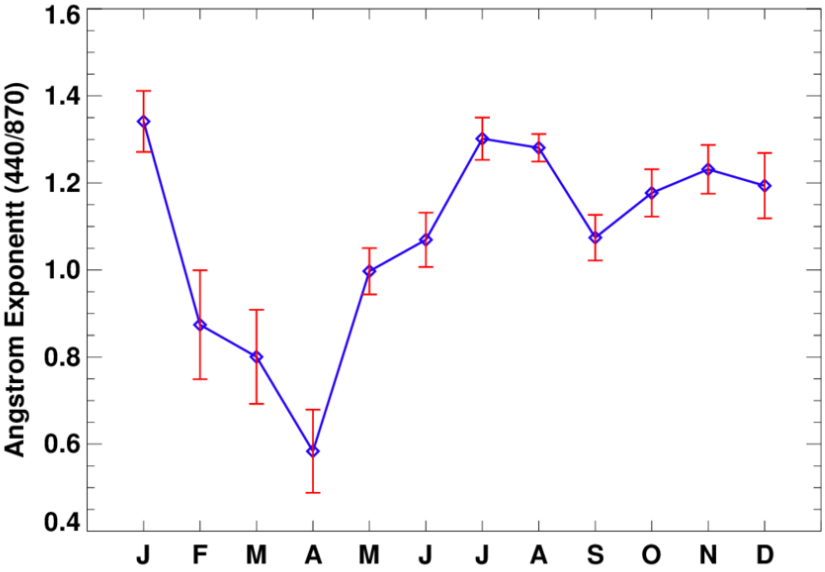


Fig (12)

long. This may be attributed to dust, (Favez et al., 2008) and anthropogenic emissions present all year. These findings agree with past studies such as Favez et al. (2008), where their study showed high background concentration of dust aerosol levels (50 μgm–3) all year long. Zakey et al. (2004) highlighted the role of sand and dust particles in increasing the aerosol optical properties in the transitional seasons (spring and autumn) during strong wind events. They also comment that the Mokatem Hills that surround Cairo are an important source of fine sand. El-Askary et al. (2008) indicated that the topography of the Delta region is an important contributor in the stagnant atmosphere and the presence of the prolonged pollution episodes. The dust aerosols are observed both within and above the planetary boundary layer (PBL), whereas the aerosols at the time of the black cloud event are confined to the PBL (Marey et al., 2010). Therefore, it is expected that there will be lower UVAI values than those found in April. In general, the daily and monthly means of UVAI indicate that both air pollution episodes (spring and fall) have absorbing features. This implies that the air pollution episodes have dust or carbonaceous particles. In order to distinguish whether the predominant aerosol type is smoke or dust, the monthly climatology of MISR size and shape-segregated aerosol AOD are analyzed. They show that the aerosols in October (time of black cloud) are spherical with higher percentage of small and medium aerosol size fractions, whereas the spring aerosols are mostly large non-spherical particles. The AERONET size distribution and AE data also show the abundance of large 20 particles during April, with more small particles during the rest of the year. Thus, result indicates that the predominant aerosol type in spring is dust. The results point out that the October Black Cloud events in the Nile region contain both dust and carbonaceous aerosols; however, the governing aerosol type is smoke. We can conclude that the high aerosol concentrations in October, during the “black cloud” are attributed primarily to 25 biomasses burning which is enhanced by emissions from vehicular, industrial, and secondary aerosols. Generally,

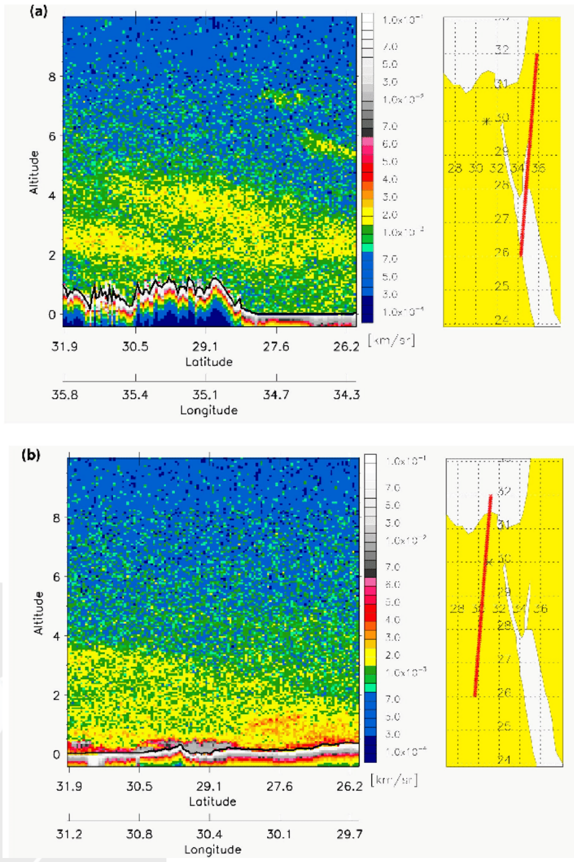


Fig (13)

aerosols coming from biomass burning consist of particles that are very light absorbing and contain significant amounts of black and organic carbon (Torres et al., 1998). Analyses of the black carbon (BC) concentrations, monitored in Cairo during autumn 2004 and spring 2005, indicates that vehicle traffic is the major source of BC in Cairo during the daytime (Mahmoud et al., 2008). The hourly concentrations are significantly larger in fall than in spring, where biomass burning emissions amplify the BC levels (Mahmoud et al., 2008). The elevated BC concentrations during the fall may be responsible for high absorbing aerosols at this time. The biomass burning emissions of rice straw generate smoke particles which mix
with the local pollution aerosols, producing various size fractions and almost spherical particles. These findings expand upon the previous results obtained of Marey et al. (2010). Since Cairo and

the Nile Delta lie between the Western and the Arabian deserts, it is not surprising that their air qualities are affected by dust during the whole 10 year, with peaks during strong spring wind events (Zakey et al., 2004). While dust aerosols contribute to enhancements the air pollution levels in the fall (Favez et al.,2008; Prasad et al., 2010). We argue that the main contributing factor to the black cloud pollution is the biomass burning of agricultural waste during the fall season. The satellite data such as MODIS, MISR, OMI, and CALIPSO provide useful complementary information to investigate the aerosol optical and physical characteristics.

If the problem is solved

- Egypt will witness development in other fields like food industry.
- Egypt will have clean environment which is crucial for the people.
- The problem of public health in Egypt will decrease drastically.
- There will be certain development in the industrial base of Egypt.
- The usage of IoT technology in Egypt will be developed.

If the problem is not solved

- Egypt will witness the spread of several types of respirational diseases because of the pollution.
- There will be degradation in the environment.
- Severe Climate change will arise.
- There will be several negative effects on agriculture.

Research

Topics related to the problem:

1.Carbon monoxide gas pollution

CO is a poisonous gas produced by the incomplete burning of carbon-based fuels. When inhaled it deprives the blood stream of oxygen, suffocating its victim. No one is immune to the effects of CO, though children 14 and under are more likely to sustain poisoning than adults at lower levels. CO can cause immediate health problems, and even death, in high concentrations, and some suspect it can also cause long-term health problems in low concentrations if a person experiences regular exposure (such as at home, or in the workplace). Significant exposure to CO can also reduce life expectancy.

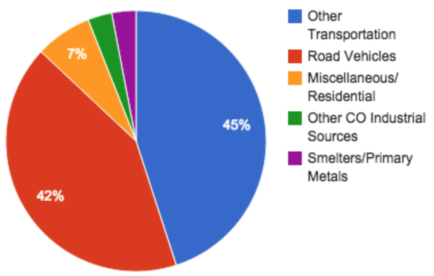
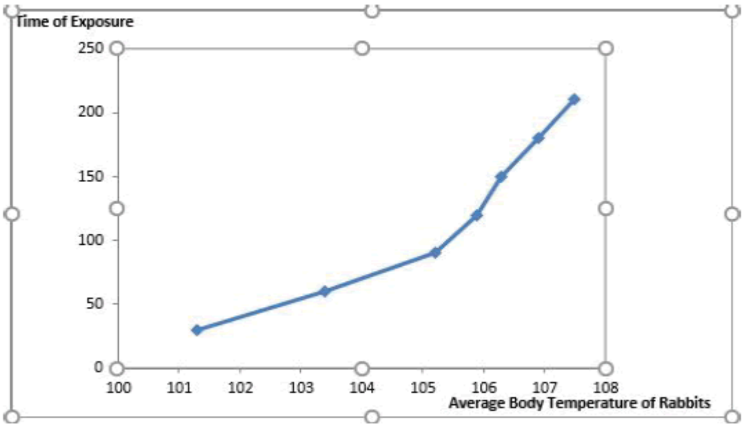


Fig (14)

Any gas or propane-based engine will produce CO, meaning that boaters, truckers, and small aircraft pilots are at risk from CO fumes as soon as they start their vehicle. Homeowners suffer the most from CO poisoning, and are in danger from sources like gas-powered furnaces and water heaters, clogged fireplaces and chimneys, cars running in an attached garage, and burning of fuels indoors (such as a gas or charcoal grill). Travelers staying in hotels are in danger of CO poisoning as well, which can be leaked into a hotel room from nearby faulty heaters and boilers.



Graph 1: Graph showing the body temperature increase of the two rabbits exposed to carbon monoxide emission from exhaust system that used catalytic converter.

Fig (15)

The beginning symptoms of CO poisoning are sometimes compared to the symptoms of food poisoning. Depending on the level of CO, and length of exposure, you may experience any one or more of the following symptoms:

Headache, dizziness, weakness and clumsiness, nausea and vomiting, quick irregular heartbeat chest pain, hearing loss, blurry vision, and disorientation or confusion seizures.

The table below summarizes some health effects due to prolonged exposure to various concentrations of CO, as well as some government recommended limits, and Pocket CO alarm levels. It has been compiled from various sources, including the NFPA:

Level of CO	Health Effects, and Other Information
0 ppm	Normal, fresh air.
9 ppm	Maximum recommended indoor CO level (ASHRAE).
10-24 PPM	Possible health effects with long-term exposure.
25 PPM	Max TWA Exposure for 8-hour work-day (ACGIH). Pocket CO TWA warning sounds each hour.

50 PPM	Maximum permissible exposure in workplace (OSHA). First Pocket CO ALARM starts (optional, every 20 seconds).
100 PPM	Slight headache after 1-2 hours.
125 PPM	Second Pocket CO ALARM starts (every 10 seconds).
200 PPM	Dizziness, nausea, fatigue, headache after 2-3 hours of exposure.
400 PPM	Headache and nausea after 1-2 hours of exposure. Life threatening in 3 hours. Third Pocket CO ALARM starts (every 5 seconds).
800 PPM	Headache, nausea, and dizziness after 45 minutes; collapse and unconsciousness after 1 hour of exposure. Death within 2-3 hours.
1000 PPM	Loss of consciousness after 1 hour of exposure.
1600 PPM	Headache, nausea, and dizziness after 20 minutes of exposure. Death within 1-2 hours.
3200 PPM	Headache, nausea, and dizziness after 5-10 minutes; collapse and unconsciousness after 30 minutes of exposure. Death within 1 hour.
6400 PPM	Death within 30 minutes.

12,800 PPM	Immediate physiological effects, unconsciousness. Death within 1-3 minutes of exposure.

Table (2)

2.Methane gas pollution

Burning one molecule of methane in the presence of oxygen releases one molecule of CO2 (carbon dioxide) and two molecules of H2O (water). Methane's relative abundance and clean burning process makes it a very attractive fuel. However, because it is a gas and not a liquid or solid, methane is difficult to transport from the areas that produce it to the areas that consume it. Converting methane to forms that are more easily transported, such as LNG

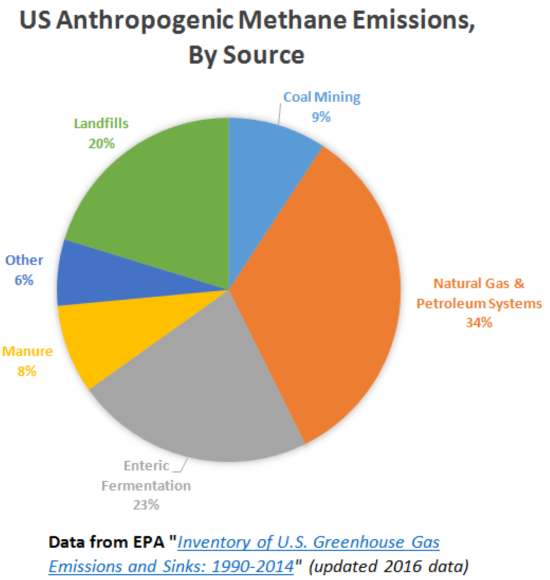


Fig (16)

(liquefied natural gas) and methanol, is an active area of research. Methane is a greenhouse gas with a global warming potential over 100 years of 23. This means that when averaged over 100 years each kg of CH4 warms the Earth 23 times as much as the same mass of CO2.The Earth's crust contains huge amounts of methane. Large amounts of methane are emitted to the atmosphere through mud volcanoes which are connected with deep geological faults or as the main constituent of biogas formed naturally by anaerobic digestion.

3.Air pollution

The air pollution in Cairo is a matter of a serious concern. The air quality in downtown Cairo is more than 10 to 100 times of acceptable world standards. Cairo has a very poor factor because of lack of rain and its layout of tall buildings and narrow streets, which create a bowl effect (bad ventilation and consequent trapping of pollutants). The main air pollution problem in Egypt is the particulate matter. The most notable sources of the dust and small particles are transportation, industry and open-air waste-burning. Another significant source is not the wind-blown from arid areas around Egypt (e.g. Western Desert).

The air in Egypt is very thick, gray and there is a haze over Cairo. Furthermore, other forms of air pollution in a carbon monoxide (CO) in streets, due to the excess amount of cars' exhaust and factories pollutants. The sky is gray rather than blue, which is very similar to the gray skies in Mexico City, London, and Beijing pollutants, of course, create a lot of respiratory diseases as the United States Environmental Protection Agency has published risk data which state that above the safe limit, the risk of developing serious respiratory diseases and cancer from inhaling particulates in the air (dust & soot, hydrocarbons, and heavy metal compounds) is: 2 people for every 1000.

4.Egypt climate

The climate in Egypt varies from surprisingly cold to extremely hot. Along the northern coast of the country the climate is Mediterranean during winter (December through March) – cool, windy and humid, with occasional rains. Sometimes Mt. Sinai can be covered with snow! Summer in Egypt (June through September) is usually very dry with extremely hot temperatures into the 90°'s and 100°'s, sometimes breaking 120° F. Many of Egypt's best-preserved sites are in desert regions where it never rains. The parched atmosphere and desert winds can sway temperatures from hot in the day to freezing at night. Shoulder seasons of April-May and October-November are particularly pleasant months to travel.

5. Interaction between carbon monoxide and methane gas.

Although carbon monoxide is only a weak greenhouse gas, its influence on climate goes beyond its own direct effects. Its presence affects concentrations of other greenhouse gases including methane, tropospheric ozone and carbon dioxide.

Carbon monoxide readily reacts with the hydroxyl radical (OH) forming a much stronger, greenhouse gas--carbon dioxide. This, in turn, increases concentrations of methane, another strong greenhouse gas, because the most common way methane is removed from the atmosphere is when it reacts with OH. So, the formation of carbon dioxide leaves fewer OH for methane to react with, thus increasing methane's concentration. A NASA report indicates that carbon monoxide is responsible for a 13% reduction in hydroxyl concentrations and through other reactions, a 9% drop in sulfate concentrations. Sulfates are credited for offsetting some of the global warming due to greenhouse gases by reflecting incident solar radiation back to space.

Topics related to the solution:

1.IoT

An IoT ecosystem consists of web-enabled smart devices that use embedded processors, sensors and communication hardware to collect, send and act on data they acquire from their environments. IoT devices share the sensor data they collect by connecting to an IoT gateway or other edge device where data is either sent to the cloud to be analyzed or analyzed locally. Sometimes, these devices communicate with other related devices and act on the information they get from one another. The devices do most of the work without human intervention, although people can interact with the devices -- for instance, to set them up, give them instructions or access the data.

The connectivity, networking and communication protocols used with these web-enabled devices largely depend on the specific IoT applications deployed.

2.MQ gas sensors

The MQ series of gas sensors uses a small heater inside with an electro-chemical sensor. They are sensitive for a range of gasses and are used indoors at room temperature. They can be calibrated more or less (see the section about "Load-resistor" and "Burn-in") but a known concentration of the measured gas or gasses is needed for that. The output is an analog signal and can be read with an analog input of the Arduino.

3.Wireless communication

The nRF24L01 is a single chip RF Transceiver IC developed by Nordic Semiconductor. It operates in the license-free 2.4GHz ISM band (ISM – Industrial, Scientific and Medical) with support for data rates of 250kbps, 1Mbps and 2Mbps. For data rates of 250kbps and 1Mbps, the channel bandwidth is approximately 1MHz. So, taking the minimum and maximum operating frequencies of 2400MHz and 2525MHz, you can implement a maximum of 126 RF Channels if your data rate is limited to 250kbps or 1Mbps. In 2Mbps data rate mote, the RF channel bandwidth should be 2MHz or more to ensure non-overlapping. There is a special feature called MultiCeiver in nRF24L01 IC. This feature enables each RF Channel with a set of 6 unique addressed data pipes so that each module can communicate with 6 other modules in the same RF Channel. Coming to the implementation of nRF24L01 IC, all you need is a 16MHz Crystal Oscillator, its supporting circuitry and an antenna. To design a Wireless Communication system using nRF24L01 Module, all you need is a Microcontroller, which is interfaced through Serial Peripheral Interface (SPI).

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The lessons we learned about the problem:

- The main issue of air pollution is the inability to control it.
- Carbon monoxide gas leakage could cause catastrophes on a personal scale and more than that.
- Egypt witnessed serious problems due to the leakage of contamination gases.
- Different levels of carbon monoxide gas could cause different diseases.
- Egypt’s climate has changed drastically since the proliferation of contamination gases.
- Carbon monoxide gas has significant effects on other environmental gases like methane gas.

The lessons we learned about the solution:

- The utilization of waves in the wireless communication makes it faster than the wired one.
- The dependence on two independent systems communicating between each other is the perfect way for achieving accuracy and speed in solving problems.
- As the gas sensors measure the levels of gases based on other factors than the gas itself, we used the same concept to search for the parameters affecting the CO levels, CH_4.
- The utilization of the platform of the IoT to achieve real-time communication among different systems.

Other Solutions Already Tried

Previous solution:

Pollution Monitoring System

Transportation is the main source for generating carbon monoxide that contributes 72% of total pollution in metropolitan cities like Cairo, Mumbai, and Delhi. In order to control air pollution, the amount of air pollution needs to be monitored and vehicles responsible for polluting should be identified. A new technique to control the vehicle causing air pollution in the cities has been developed. This proposed system is designed with an ARM7 processor that controls the engine of the vehicle. Any vehicle exceeds the threshold level of pollution in an area then the engine of the vehicle was automatically switched off by the circuit.

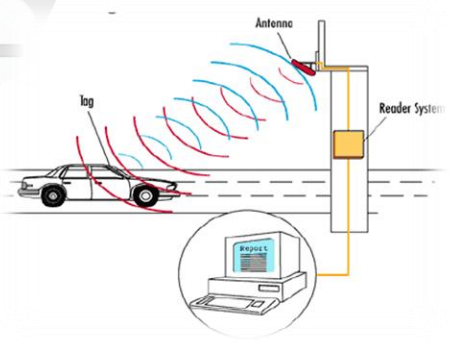


Fig (17)

The vehicles inbuilt with this system are controlled. Wireless sensor along with active RFID is used in the proposed wireless sensor system to monitor vehicular pollution based on IoT. The framework of the proposed system uses IoT to address vehicular pollution in real-time applications. Two gas sensors CO2, SOx are used to monitor the pollutants continuously to maintain the quality of the air. At monitor location, the RFID reader, wireless gas sensors are integrated along with microcontroller. This entire system is placed in either of the roads. Whenever the vehicles equipped with RFID tags passed through the sensor node, RFID reader presented in the monitoring system detects the vehicles and the sensors measure the quality of the air produced by that vehicle. The sensed continuous data is sent to the microcontroller for verification of the pollution level of the vehicle. The microcontroller verifies the levels of the pollutants of the air produced by the vehicle. If the pollutants levels are beyond the threshold levels, then it sends the warning message to the vehicle owner. The same data is displayed on the Liquid Crystal Display (LCD). The information about the levels of CO2 and SOx, vehicular number, RFID of the vehicle and time and date of the vehicle are also sent to the server of the authorized agencies. This information is stored in the server database for future analysis.

The hardware of the proposed air pollution monitoring system mainly consists of Arduino microcontroller development board, ATmega328 microcontroller, MQ Gas sensors, EM-18 RFID reader and RFID tag. ATmega328 microcontroller: It is a low power and high-performance microcontroller used to read and control the data from sensors and RFID reader. It sends the data to server and LCD display for displaying the pollution level and RFID ID. Arduino board: Arduino is a hardware source platform that can work with different communication technologies and sensor devices. Due to its simplicity and number of hardware extensions, more users and developers are using the Arduino. Wireless Gas Sensors: In this research work MQ-7, the MQ-2 gas sensor is used to measure the carbon dioxide and sulfur oxides concentration in air. Radio Frequency Identification: RFID technology is used for detecting, tracking and finding the location of vehicles. A prototype was developed for the integration of all the devices and the prototype is tested. The information on
RFID card sends serially to Arduino board through active RFID reader. The Arduino microcontroller board read the data and also sends the data to terminal and server using IoT.

The reason behind this solution being inapplicable is its high cost. Despite its great benefits to the environment, it still can cause disastrous consequences, one of which is the instantaneous halting of the vehicles that can kill the driver.

Current solution:

Air Pollution Monitoring System

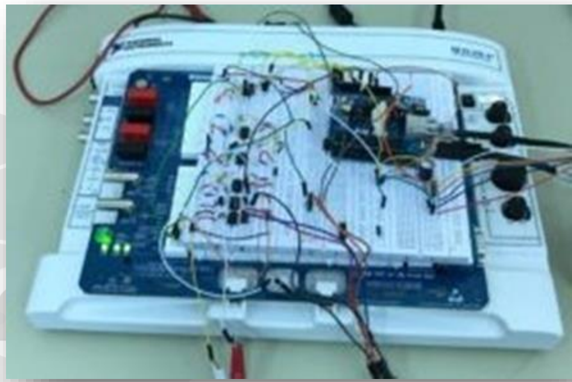


Fig (18)

In the previous years, the pollution levels due to different industries and urbanization have been rising dramatically, making it crucial to have a trusted and technologically advanced way of measuring and monitoring some of the most important air elements, including CO2, dust, and temperature, in order to be able to keep track of how some of the current civilization acts such as forests cutting, increased use of vehicles and other industrial acts endanger not only our health but also the environment.

A system that measures CO2, dust and temperature from surrounding environment and sends data to users using Blynk application. International standards are used for alerting the user. The system uses inexpensive sensors to measure CO2 (M3811 CO2 sensor), dust (GP2Y1010AU0F) and temperature (LM 35). Each sensor is followed with electronics transducer in order to amplify and filter out the noise signals. After that, Arduino Microcontroller is used as a data acquisition system to convert the analogue signals into digital signals. In order to track the system in real time, a communication solution has been introduced using the Arduino Ethernet shield. To display the readings of sensors remotely, Blynk mobile application has been used, where Blynk is a platform used to design a mobile application to interact with IoT devices.

The system gives real-time measurements. High accuracy with an error equal to 2% with respect to a reference device. The temperature sensor has been calibrated manually. Readings are displayed in various ways including graphical way. Data is stored in Blynk Cloud for further studies by experts. Alert users when the amount of CO2 and dust goes beyond the international standards.

The reasons behind this solution being poor are:

- It is not available for domestic uses because of its complexity.
- It gives restricted results according to the area where it has been set to work in.

What lessons can we learn from previous attempts to solve this problem?

- Choosing accurate sensors to measure the main data.
- Rely on stable communication among our systems to increase efficiency.
- Displaying data in various ways (tables, graphs,).

Design Requirements

Design requirements for the prototype:

- The carbon monoxide gas returns to its normal level (50 ppm) after the alarm.
- The emergency door opens once methane level exceeds the threshold level (1000 ppm).

Measurements:

1. Using the MQ-7 sensor to measure carbon monoxide level after the purification is done.
2. Comparing the output value with the normal carbon monoxide level (50 ppm)..:
3. sketching various data from the gas sensor and observed the response of the servo.

The chosen real solution must have the following characteristics:

1. The system must be flexible and easy to be installed.
2. The system is durable and consists of sustainable materials.
3. the system uses accurate tools to get credible data.
4. the system has fast response rate for emergencies.
5. The solution optimizes real-time, wireless communication among different systems using IoT technology.

Selection of Solution

How did we select our solution?

As we are targeting to reduce the consequences of the contamination caused by leaked gases – like CO and SO_x, we choose the steel industry for its incidents about the death of millions of workers. In fact, not only might the steel industry kill the workers, but also affects the environment negatively. Such disastrous effects could be reduced by not stopping the source, but rather restraining its aftermaths. Our solution consists of two systems: one for the alarm and the purification and another for the physical actions taken by a servo to open the doors according to a CH_4 sensor – CH_4 increases proportionally with CO. So, it will decrease the probability one could die by the leaked gases.

How does it work?

The two systems of our solution work coherently by exchanging data and orders in order to save people's lives as fast as possible. The first system is composed of an air purification machine, which takes about 20 minutes to clean up the whole factory from the leaked gas. Also, we put a carbon monoxide sensor to measure the amount of CO in the air in ppm (parts per million). An alarm is connected in phase with a sensor to warn the people out whenever there is a leakage. The second system comprises a methane sensor to measure the CH_4 concentration in the air and a servo to open the doors of the factories immediately after detecting the gas by the methane sensor.

What is the importance of each part?

1- CO Sensor:

A carbon monoxide detector or CO detector is a device that detects the presence of the carbon monoxide (CO) gas in order to prevent carbon monoxide poisoning.

2- Methane Sensor:

A Methane Gas Sensor is a device used as an integral part of a fixed gas detection system for the purposes of monitoring and detecting levels of methane in air in % LEL (Lower Explosive Limit) levels or in percent by volume levels.

3- Arduino UNO:

It is the software device, via which you can test various circuits. It is based on the microcontroller Atmel series. It has its own CPU along with a control unit and arithmetic, logic unit and memory. It has software called IDE where we work on and type the code and instruction, and all of the codes are written in Arduino C language. We used the Arduino to control on the CO sensor, CH_4 senor and consequently, the air purifier, the servos, the alarm.

4- Air purifier:

An air purifier or air cleaner is a device which removes contaminants from the air in a room. These devices are commonly marketed as being beneficial to allergy sufferers and asthmatics, and at reducing or eliminating second-hand tobacco smoke.

5- The alarm (Buzzer):

A buzzer or beeper is an audio signaling device, which may be mechanical, electromechanical, or piezoelectric (piezo for short). Typical uses of buzzers and beepers include alarm devices, timers, and confirmation of user input such as a mouse click or keystroke.

6- Servo:

The function of the servo motor is to receive a control signal that represents a desired output position of the servo shaft and apply power to its DC motor until its shaft turns to that position.

The first system:

Whenever a gas is leaked from the pipes, the CO sensor will the detect the leaked gas (CO). Then, the sensor will send the readings to its controller Arduino, and the Arduino will evaluate the readings according to a threshold reading – a threshold at which the concentration of CO is killer. At the threshold, the Arduino will set off the alarm, and send instruction to the air purifier to be switched on.

The second system:

As the gas spread out, it will consume all the $(OH)^-$ ions in the air resulting in an increase in the methane concentration. We put a methane sensor to measure its concentration in ppm and send it to its controlling Arduino. The Arduino will in turn sends brief to the servo to open the factory gates.

The interactions between the two systems:

Firstly, while the alarm of the first system is switched on, the methane sensor will detect the gas. As soon as the servo is turned on, the second system's Arduino will send transmit data to the first system's Arduino to switch off the alarm – while the air purifier is working. After an estimated time-interval, according to each factory, for the people to be able to get out from the gates, the second Arduino will send instructions to the servos to close the gates. After the air purifier takes about 20 minutes to clean up the factory, the first

Arduino will switch off the air purifier and sends data to the second Arduino about the status of the carbon monoxide levels. Then, the second Arduino will evaluate the values to or not to open the gates again for the people to get in. When the normal CO percentage in the air is reached, the second Arduino will tell the servos to open the gates. But, if not, it will resend data to the first system to re-turn on the air purifier till it reaches the desired concentration of the CO.

How will our solution meet the design requirements?

1. Its materials are available, economical, and cheap.
2. The systems respond to the leaked gas instantly after detecting the gas.
3. It’s eco-friendly and doesn't radiate any harmful waves.
4. It consumes small packets of electrical energy.
5. Our device measures the CO, CH4 values in the atmosphere according to a Carbon monoxide and a Methane sensor, that is, doesn't depend on any other factor other than the CO and CH4 levels.
6. The communication between the systems in conducted by an antenna that could transmit waves up to one kilometer far.

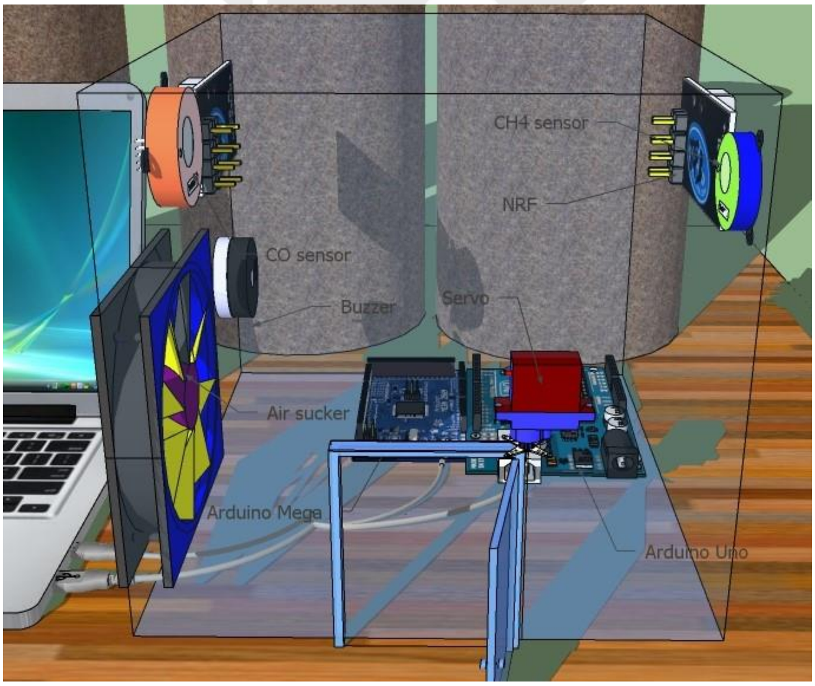


Fig (19)

Selection of prototype

At the beginning, we have chosen our design requirements on the bases of the most common circumstances that could occur inside a restricted area. For the first design requirement, it was to measure the concentration and levels of the CO gas in the atmosphere accurately on both cases of normal levels and extreme ones. Hence, we bought a CO sensor that measure the carbon monoxide levels. We also used an Arduino that is a microcontroller to receive the readings from the sensor. After measuring the CO levels, the sensor will send them to the Arduino to which it is connected to evaluate the readings based on a certain limit we've determined before. The second design requirement is to measure the levels on the CH4 in the air. Those levels have risen up because of the increase of the CO levels since it affects the methane concentration proportionally. We also wanted to measure such levels in both the normal conditions and extreme ones. Thus, we brought a CH4 sensor to measure the levels of the methane in the air, which is affected by the CO level, and send them to the Arduino to which it is connected to evaluate the reading according to a certain limit we've chosen before. Both limits of CO and CH4 are prompt killers to the human body. We used the Arduino microcontroller rather, than a respray pie, in both sensor because it is cheaper, consumes low energy, is applicable and easy to use. We included every component in an acrylic box to save them from water. Buying all the materials we needed, we calculated the cost to be 985.LE.

Our prototype is divided into four parts:

1-The first System

For the air to be sucked out of the box we have made, we needed an air sucker (fan) to get out of the harmful gases (CO, CH_4). For the people to be warned out, we used a buzzer which is connected to the Arduino, and it will be switched on in any case of excess of the limits we have determined for the levels of the gases. For the conditions to be applied and the coding to be interpreted in term of physical actions, we used an Arduino Uno to translate the code and switch on and off the other components in certain situations. For the electricity to distributed widely for each component to acquire its electrical energy, we used a bread board which has the ability to transfer the current from the Arduino to all of the components. For the mechanism of the first system, whenever the percentage of CO exceeds a certain limit (50 ppm), the CO sensor will detect the changes. The CO sensor will, then, send its measurements to the Arduino, to which it's connected. The Arduino will evaluate the readings of the sensor according to a certain limit. If the value of the CO exceeds its limit, the Arduino will switch on the air sucker and the alarm. The air sucker will eliminate the high values of the CO, and the alarm will warn the people of the existence of the toxic gas.

2-The second system

To rotate the doors to open in case of any leakage, we used a servo device that is capable of rotating a 1 kg door. For the communication between the systems – IoT, we used a trans receiving antenna to that has a range of 1 km and is able to send and take data, instructions, and signals. For the mechanism, as soon as the CO percentage increases, it will affect the percentage of the CH4 proportionally. The CH4 will detect the rise in the percentage and sends them to its Arduino. The Arduino will, in turn, compare the measurements to a certain limit (1000 ppm). If the level of the CH4 exceeds the limit, the Arduino will instantaneously send instructions to the servo to open the gates for the workers to facilitate their way out.

3-The communication between the systems

The two systems work independently at the beginning. As the people are coming out, the air sucker will be still cleaning the leaked gas. Nevertheless, after a 2-minute dilation, the second system will communicate with the first system to stop the alarm. Afterwards, the Arduino of the second system will make the servo close the door till the air sucker finishes the cleaning efficiently. The air sucker will take 3 minutes to clean up the whole gas. After that, the second system will apply the condition it was set to – if the air sucker is turned off, open the servos. The doors will open up for the workers to enter the factory.

4-The coding

We used Arduino 1.8 program and C-programming language to debug our code. We sit pin numbers in variables and we defined them each one with an abbreviation to ease the process of writing.

System (1):

In lines 1,2, and 3, we included the libraries of the NRF (antenna) for the code to be operational. For the view the readings on the screen, we constituted the library for the serial monitor (line 3). The text in green is for the comments for us to be aware of the pin and their variables. For line 9 and 10, we wrote the code for the pins in which the NRF is connected and its address. We defined two variables t, r, limit, and value that will be used later. After that, we set the pins of the CO sensor, the led, the fan, and the buzzer. We wrote the serial monitor code to display the readings, and then set the address for the NRF to send on.

```
01. #include <SPI.h>
02. #include <nRF24L01.h>
03. #include <RF24.h>
04. #include <printf.h>
05.
06.
07.
08. /* anntenaaaaaaaaaaaaaaaaaaa */
09. RF24 radio(7, 8); // CE, CSN
10. const byte addresses[][6] = {"00030","00031"};
11. bool role = 0;
12. int r=1;
13. int t=1;
14.
15. /* MQ-7 Carbon Monoxide Sensor Circuit with Arduino */
16.
17. const int AOUTpin=0;//the AOUT pin of the CO sensor goes into analog pin A0 of the arduino
18. const int DOUTpin=4;//the DOUT pin of the CO sensor goes into digital pin D8 of the arduino
19. const int ledPin=13;//the anode of the LED connects to digital pin D13 of the arduino
20. const int fanPin=10;//the anode of the fan connects to digital pin D13 of the arduino
21.
22. int limit;
23. int value;
24.
25. const int buzzer = 9; //buzzer to arduino pin 9
26.
27. void setup() {
28. Serial.begin(115200);
29.  radio.begin();
30. radio.openWritingPipe(addresses[1]);
```

Fig (20)

We adjusted the pins as inputs for the CO sensor, the led, and the buzzer. We put into the value of the previously defined variables as the analog and digital reading of the CO sensor. We instructed the CO to view its measurements on the serial monitor.

```
radio.openReadingPipe(1,addresses[0]);
  radio.setPALevel(RF24_PA_MIN);

 // Start the radio listening for data



pinMode(DOUTpin, INPUT);//sets the pin as an input to the arduino
pinMode(ledPin, OUTPUT);//sets the pin as an output of the arduino
pinMode(buzzer, OUTPUT); // Set buzzer - pin 9 as an output


}

void loop()
{


limit= analogRead(AOUTpin);//reads the analaog value from the CO sensor's AOUT pin
value= digitalRead(DOUTpin);//reads the digital value from the CO sensor's DOUT pin
Serial.print("CO value: ");
Serial.println(value);//prints the CO value
Serial.print("Limit: ");
Serial.print(limit);//prints the limit reached as either LOW or HIGH (above or underneath)
delay(100);

if (limit >  50){
  digitalWrite(ledPin, HIGH);
  }
  if(limit > 50 && t==1){
```

Fig(21)

We informed the Arduino of the conditions we ultimately decided on; That is, when the level of CO, included in the variable limit, exceeds the limiting value (50), turn on both the Led and the buzzer and make a delay for the tunes spreading out from the Buzzer. After that, the NRF should start receiving data from the

```
  if(limit >150 && t==1){
tone(buzzer, 1000); // Send 1KHz sound signal...
  delay(1000);         // ...for 1 sec
      // Stop sound...
  delay(1000);
  role =0;


if(role==0 && r==1){
  radio.startListening();
  char text[]="";
  if (radio.available()) {
    while (radio.available())  // While there is data ready
    {
  radio.read(&text,sizeof(text));}
  if(text=="buz"){
  t=0;
  noTone(buzzer);
  Serial.println(text);
  role=1;
  r=0;}
  }
  delay(1000);
}
  }
  if(limit < 50 && t==0){
  if (role == 1 && r==0)  {
  radio.stopListening();
```

Fig(22)

antenna of the second system. We constituted another condition that is when the other NRF sends a test of "buz", switch of the buzzer. Another condition we've set in case of not exceeding the value; that is, if the value if the CO is less the limiting value, the NRF stop listening from the antenna of the second system.

Also, as an additional sign for us when the system didn't reach the limiting value yet, the serial monitor will propound a text, now sending. As a final condition, when the levels of CO and CH4 reached its normal value, turn off the Fan and the led.

```
    radio.stopListening();
    Serial.println(("Now sending"));
    const char rec[] = "servo";
    radio.write(&rec, sizeof(rec));
    delay(1000);
    role=0;
    r=1;
  }
    }
    if (limit >  50) {
  digitalWrite (47,1);
  digitalWrite (45,0);
    }
    if (limit < 50) {
  digitalWrite (47,0);
  digitalWrite (45,0);
    }
```

Fig (23)

System (2):

We included the libraries of the servo, the NRF (antenna), and the serial monitor in the first 5 lines. We defined the address of the

```
01. #include <Servo.h>
02. #include <SPI.h>
03. #include <nRF24L01.h>
04. #include <RF24.h>
05. #include <printf.h>
06. /* antenaaaaaaaaaaaaaaaaaaaa */
07. RF24 radio(7, 8); // CE, CSN
08. byte addresses[][6] = {"00030","00031"};
09. bool role = 0;
10. int r=1;
11. int t=1;
12.
13. Servo servo_test;        //initialize a servo object for the connected servo
14.
15. int angle = 0;
16.
17.
18.
19.
20.
21. const int AOUTpin=0;//the AOUT pin of the nh4 sensor goes into analog pin A0 of the arduino
22. const int DOUTpin=4;//the DOUT pin of the nh4 sensor goes into digital pin D8 of the arduino
23. const int ledPin=13;//the anode of the LED connects to digital pin D13 of the arduino
24.
25. int limit;
```

Fig (24)

NRF and set the variables with their initial values for their utilization later. We initialized the angle of the servo as 0 to start with the door closed. We wrote the pins numbers for the CH4 sensor and the led and set them as constants.

We attached the signal pin of the servo to Pin 9 of the Arduino. We wrote the serial code for the serial monitor to display the readings of the methane sensor. Then, we comprised the address on which the antenna will send. We defined the pins of both the Methane sensor and the led as inputs. We set the values of the variables (value) and (limit) as the digital and the analog readings of the Methane sensor, and then made a delay for the displaying of the measurements for us to be able to distinguish each one of them.

```
int value;


void setup() {
 servo_test.attach(9);      // attach the signal pin of servo to pin9 of arduino
servo_test.write(65);
Serial.begin(115200);
 radio.begin();
 radio.openWritingPipe(addresses[0]);
 radio.openReadingPipe(1,addresses[1]);
  radio.setPALevel(RF24_PA_MIN);
  pinMode(DOUTpin, OUTPUT);//sets the pin as an input to the arduino
pinMode(ledPin, OUTPUT);//sets the pin as an output of the arduino


}
void loop()
{

limit= analogRead(AOUTpin);//reads the analaog value from the CO sensor's AOUT pin
value= digitalRead(DOUTpin);//reads the digital value from the CO sensor's DOUT pin
Serial.print("ch4 value: ");
Serial.println(value);//prints the CO value
Serial.print("Limit: ");
Serial.print(limit);//prints the limit reached as either LOW or HIGH (above or underneath)
delay(100);
```

Fig (25)

We set the conditions for the interaction between both the two systems and the components of the second system. Firstly, when the level of the Methane exceeds its limit (1000 ppm), the led will be turned on, and the servo will begin to open the doors at an angle 65 from 0. We then wrote a line for the servo to be rotated to a certain angle. After that, we ordered the NRF to send the text "buz" – stop the buzzer – when the servo is turned on.

```
if (limit >1000){
digitalWrite(ledPin, HIGH);//if limit has been reached, LED turns on as status indicator
}
if (limit >1000 &&t==1){
for(angle = 65; angle > 0; angle -= 1)    // command to move from 0 degrees to 180 degrees
  {
    servo_test.write(angle);                 //command to rotate the servo to the specified angle
    delay(15);

 }
  delay(5000);

  for(angle =0; angle<=65; angle +=5)     // command to move from 180 degrees to 0 degrees
  {
    servo_test.write(angle);              //command to rotate the servo to the specified angle
    delay(5);
    role=1;
    r=0;
  }
}
    delay(1000);

if (role == 1 && r==0)  {
  radio.stopListening();
  Serial.println(("Now sending"));
  const char text[] = "buz";
```

Fig (26)

We then instructed the Arduino to rotate the servo again to an angle zero after a certain, after the people came out, and sends information to the first NRF that the servo is closed. When the value of the Methane reaches its normal value, the NRF sends the values to the first Arduino for the fan to turn off. After that, the Arduino will open he servo again for the people to get in.

```
  radio.write(&text, sizeof(text));
  delay(1000);
  role=0;
  r=1;
  t=0;
}




if (limit <1000 &&t==0){
radio.startListening();
  char rec[]="";
  if (radio.available()) {
    while (radio.available())  // While there is data ready
    {
  radio.read(&rec,sizeof(rec));}
  if(rec=="servo"){
  Serial.println(rec);
  role=1;
  r=0;
  for(angle = 65; angle > 0; angle -= 1)    // command to move from 0 degrees to 180 degrees
  {
    servo_test.write(angle);              //command to rotate the servo to the specified angle
    delay(15);    }
```

Fig (27)

We made the delay for the reading to be sent to the other NRF. As an additional case, if the limits value isn't reached yet, keep the LED off.

```
    delay(15);    }
  }
  }
  delay(1000);
}

else{
digitalWrite(ledPin, LOW);//if threshold not reached, LED remains off
```

Fig (28)

Functions:

We used some functions to make us achieve our requirements like:

- pinMode: determines the state of the connected pin.
- digitalWrite: rotates the motor in periods by giving high or low values to the digital pins.
- Delay: determines time of the periods.
- Serial.Print: prints data to the serial port as human-readable text.

- Analog read: defines analog value to the specified port on the device.

How will we test it?

For the CO measurement, the CO sensor will read the levels of the carbon monoxide in the air and represent them in a serial monitor from which we can know whether the readings match the actual values or not.

For the CH4 levels, the CH4 measures its levels synchronistically with the levels of the CO. The readings are viewed on the serial monitor of the Arduino of the second system from which we can determine whether the CH4 levels in the air is proportional to the CO levels.

For the communication between the systems, we connected them to two antennas, and then the system exchanged some information and instruction. After that, we wrote our condition - when the servo is switched on, stop the alarm, and if first applied the condition, it is successfully trans receiving data.

As a conclusion, we deduced that our device could be test in various ways to meet the design requirements as we test it successful and it showed that it superbly solved problem and the grand challenge we have chosen.

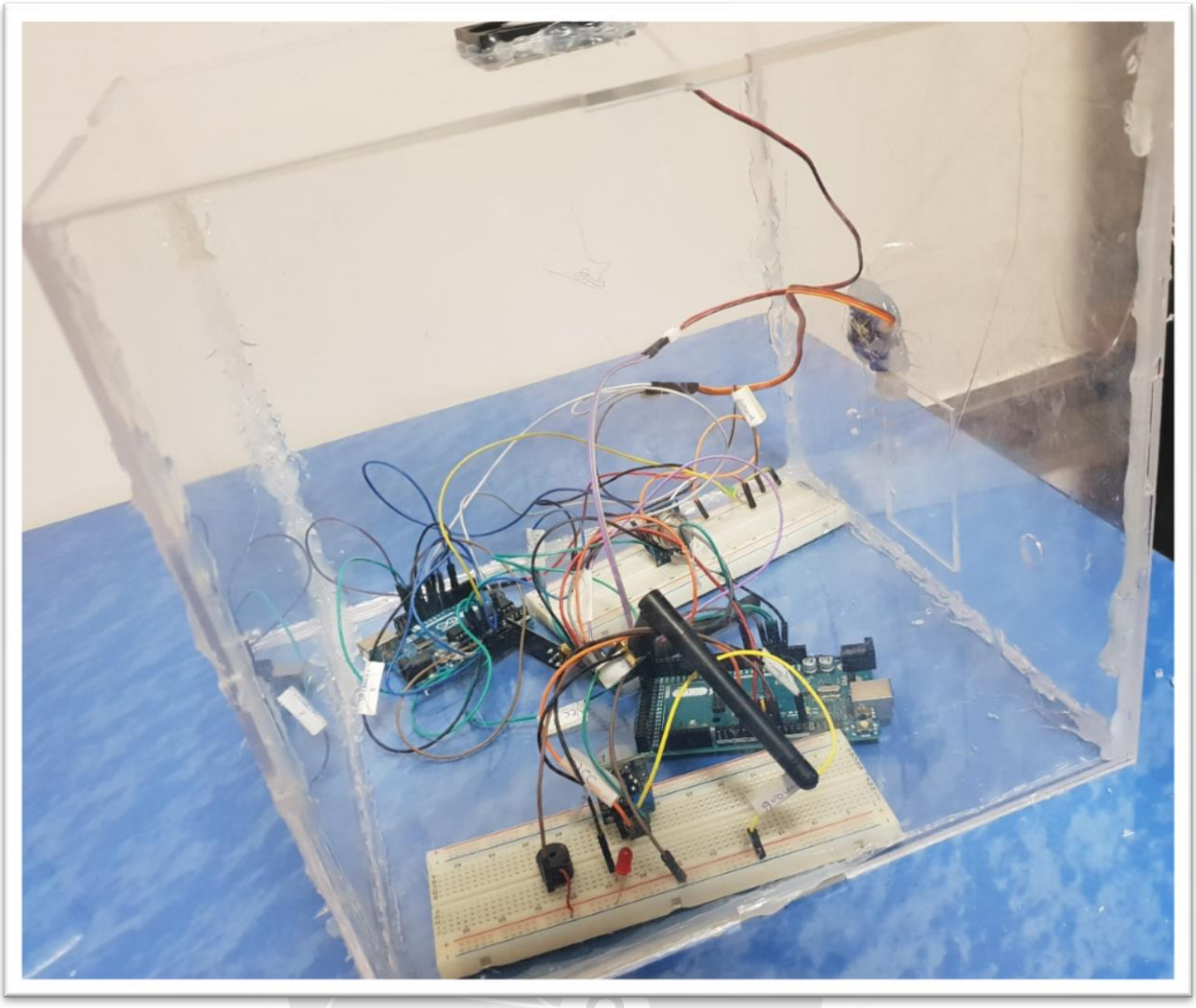


Fig (29)

Materials and Methods

Material	Quantity	Source	Cost	Picture
Arduino Mega	(x1)	Makers electronics	240 L.E	
Arduino Uno	(x1)	Makers electronics	100L.E	
MQ-5 gas sensor	(x1)	RAM electronics	45 L.E	
MQ-7 carbon monoxide sensor	(x1)	RAM electronics	55 L.E	

Servo	(x1)	Makers electronics	45 L.E	
Buzzer	(x1)	Makers electronics	5 L.E	
nRF24L01 2DB Antenna	(X2)	Future electronics	300 L.E	
DC fan	(x1)	Electra	20 L.E	

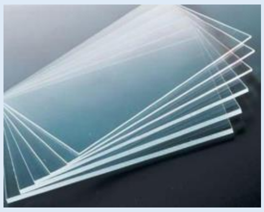
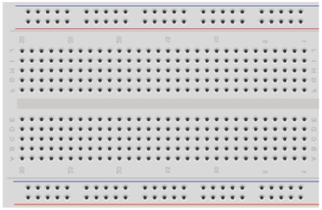
Acrylic	(X6 squares (30x 30 cm^3))	Fab lab	150	
Breadboard	(X2)	Makers electronics	25 L.E	
Total			985 L.E	

Table (3)

The functions of the materials:

Material	Function
Arduino Mega	To give instructions to the sensors and actuators.
Arduino Uno	To give instructions to sensors and actuators.
MQ-5 gas sensor	To measure the level of carbon monoxide gas.
MQ-7 carbon monoxide sensor	To measure the level of methane gas.
Servo	To move the emergency door.
Buzzer	To produce the alarm sound.

nRF24L01 2DB Antenna	To achieve communication among the two systems.
DC fan	To purify air by sucking CO gas
Acrylic	To create our box
Breadboard	To connect the microcontroller with the sensors and actuators.

Table (4)

Methods

First of all, we made a 28 cm3 acrylic (3mm) container to resemble the contamination area.

System 1:

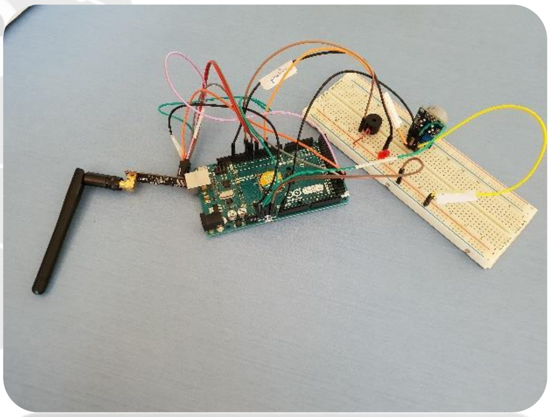


Fig (30)

1. Setting the Arduino Mega with the breadboard.
2. Connecting and configurating the MQ-7 carbon monoxide sensor to the Arduino.
3. Connecting the buzzer to the Arduino.
4. Connecting the Arduino to the DC fan.
5. Using an Arduino C IDE to give instructions to our sensors and actuators.

System 2:

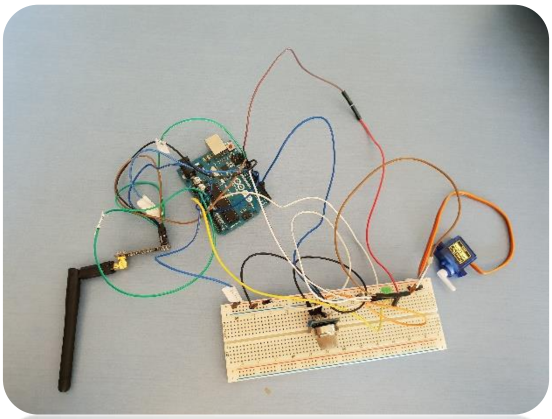


Fig (31)

1. Setting the Arduino Uno with the breadboard.
2. Connecting and calibrating the MQ-5 gas sensor to the Arduino.
3. Making one opening in the acrylic to resemble emergency door.
4. Fixing a servo on the opening (the door) in the container.
5. Connecting the servos to the Arduino.
6. Using Arduino C IDE to program the gas sensor and the servo.

The connection between the two systems:

1. Connecting the nRF24L01 2DB Antennas to the Arduino Mega and Uno.
2. Connecting the two systems using (RF24) library then sending and receiving the target data.

Afterwards, we fixed each component in its position inside the container.

Safety Precautions

We followed some safety rules when dealing with chemicals like the (CO) or (CH_4) gases.

1-Always wear lab coat and gloves when you are in the lab. When you enter the lab, switch on the exhaust fan and make sure that all the reagents required for the experiment are available. If they are not available, prepare the reagents using the components for reagent preparation.

2-Make sure that the milk you are using is not skimmed milk. Commercially available packet milk will be skimmed, so the fat content will not be present, and you will not have to do the centrifugation part of the experiment.

3-Care should be taken while handling caustic acids like Conc. Hydrochloric acid (HCl). These acids should be prepared in FUMEHOOD only. However, the prepared 0.2N HCl can be opened and used on the lab bench as it is weakly acidic.

4-Calibrate the pH meter with standard buffer before you start to do the experiment. Make sure that the pH meter is working properly.

5-Wash the pH electrode thoroughly with distilled water and wipe the electrode smoothly. Care should be taken to ensure that lint-free tissue paper is used to wipe the pH electrode.

6-Do not immerse the electrode into the solution deeper than 20mm.

7-There will be fluctuations in pH reading when the electrode is dipped into the solution, so make sure to wait long enough for the reading to stabilize.

8-Once the reading has been taken, immediately remove the electrode from the sample and rinse properly with distilled water.

Test plan

Design requirements:

- The carbon monoxide gas is detected and returns to its normal level (50 ppm) after the purification.
- The emergency door opens once methane gas level exceeds the threshold level (1000 ppm

First test

Goal: Proving the first design requirement which is detecting CO gas and purifying it.

Tools used: MQ-7 carbon monoxide sensor

Procedures:

1. We used the MQ-7 sensor to measure carbon monoxide level after the purification was done.
2. We compared the output value with the normal carbon monoxide level (50 ppm).

Second test

Goal: proving the second design requirement which involves opening the emergency door once methane exceeds the threshold level.

Tools used: MQ-5 gas sensor

Procedures:

We sketched various data from the gas sensor and observed the response angle of the servo.

Is this test plan written in a way that supports repetition and testing by others?

Our test plan supports repetition for some reasons:

1. The measurement tools are available.
2. The steps are easy and convenient.
3. The resulted data are accurate and presented in graphs and tables.

Factors that might affect the results:

1. Other gases concentrations in ambient air.
2. The uncertainty in the sensitivity of the gas sensors.

Data collection

Test 1

Goal:

The carbon monoxide gas is detected and returns to its normal level (50ppm) after the purification.

Observation:

Firstly, we used a small DC fan to suck CO from the air; after that, we got the following data for carbon monoxide concentrations (PPM) after three trials:
*the sensor has a sensitivity uncertainty of (± 0.1)

Trial	CO concentration (PPM)	Normal level (PPM)
1	53± 0.1	50
2	54± 0.1	50
3	51± 0.1	50

Table (5)

From the results, we observed that the obtained values are not accurate, so we replaced the DC fan with different one and readjusted the MQ-7 sensor. So, we obtained the following results:

Trial	CO concentration (PPM)	Normal level (PPM)
1	50± 0.1	50
2	50± 0.1	50
3	51± 0.1	50

Table (6)

Conclusion:

These results are more accurate and compatible with our design requirements.

Test 2

Goal:

The emergency door opens once methane level exceeds the threshold level (1000 ppm).

Observation:

We sketched various data from the MQ-5 sensor and observed the response of the servo:
*the sensor sensitivity has an uncertainty of (± 0.1)

Table (7)

Trial	CH4 gas concentration (PPM)	Angle displaced by the servo in (degrees)
1	900± 0.1	0
2	1010± 0.1	90
3	1200± 0.1	90

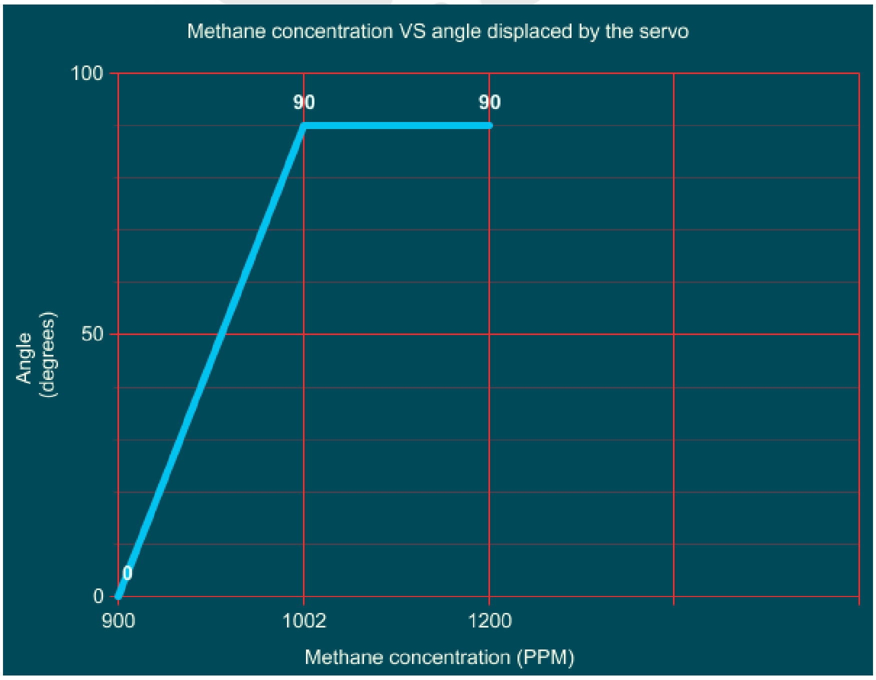


Fig (32)

Conclusion: The test results met the design requirements.

Level of precision

We achieved high level of accuracy and precision as the results were consistent because we followed sequence of steps:

- Taking Average for the values we measured.
- Taking significant figures for each measurement.

We measured the systematic error of the values of weight of water and specimens and it is equal to ± 0.1 %.

Measurement tools

1. MQ-7 sensor: used to measure carbon monoxide level in air
2. MQ-5 sensor: used to measure methane level in air

Discussion

What did the results find after our data collection?

Our results indicated that our project has achieved the design requirements successfully and met the expected results. Our solution is not influenced by any weather conditions as the device is only dependent om the electricity it consumes. It works perfectly during winter as well as summer. Our solution dissipates small amounts of energy, 61.407. Such a value of power is not effective on the overall consumption. Our device is eco-friendly because it does not produce any harmful gases or any abnormal temperatures during work. Our device is applicable everywhere; it could be used to clean the air and alarm the people in the stores, companies, and schools because it works automatically and facilitates an easy way out for the people. Our solution is portable and easy to be installed.

Were our conclusions accurate enough?

There is no doubt that any solution has its own defects and inaccurate results that will inform the user know of the precise output. Nevertheless, our device has a negligible error range that does not affect its purposes, which we determined before. Our solution was more accurate than we have ever expected as it produced results that gave us an extreme satisfaction. Nonetheless, our solution has achieved the desired design requirements with an error in a range of ± 0.1% in the CO, CH_4 measurements. Our device has an ± 3 sec time range to react to the leaked gas, yet the time it takes for the two systems to communicate is negligible.

Did the data demonstrate whether the prototype met the design requirements?

Our solution met phenomenally the design requirements with just an overall average error of ± 0.5 in each measurement. For the CO measurements, we used the MQ-7 to measure the levels of carbon monoxide in the air and compared it with normal outside level. The CO responded with the increase in the CO values and measured its normal level accurately. For the response of the servo to the CH4 sensor, we sketched various data from the gas sensor and observed the response angle of the servo. The servo responded almost instantaneously to the increase and decrease of the levels of CH4 in the air. So, the data showed that our device is more successful than the previous ones in treating the pollution in restricted areas.

Recommendations

What recommendation do we have for future work in this area?

- Replacing the servos by an impeded rotating system into the gates of the factory.
- Utilizing our device in various industries and in restricted areas like stores and moles.
- Developing a mobile application for the workers to be informed when the air purifier finishes cleaning.
- Replacing the air sucker (fan) by an air purifier for more efficiency.

- Installing many sensors in various places to measure the leakages simultaneously.
- Replacing the buzzer with an alarm to make all the workers hear the warning.

What would we tell another team who wanted to start where we stopped on our solution to help them?

- Replacing the methane sensor by a people amass sensor that measures the random motion of the workers for further accuracy.
- We recommend the user company to develop our device by exploiting it to measure more leakages other than the CO leakage.
- In case of a device failure, the workers will use a mobile application to indicate whether they feel any symptoms. The application will decide on if the symptoms indicate a certain leakage, and the device will then check for that.
- Merging each system with its components together for the simplicity in the usage.

Learning outcomes

Learning outcome	Explanation
➢ ME.3.01 - Students will be able to use vector Cross	➢ Torque or moment is the tendency of a force to rotate an object about some axis. In another way, we can say that It is a twisting force that tends to cause a rotation of a

Product to determine torque on an object produced by a force.	physical object. It can be calculated from the relation T=rfsin(x); where (r) is the distance between the rotation axis and the point of the applied force (f), (x) is the angle between the applied force (f) and the distance to the point of axis of rotation. It is measured in N.m. according to the SI units. As F=mg, we could determine the weight of door and the required force to rotate it. Hence, we could determine the type of the servo that is adaptable, concise, flexible, and compatible in the process of opening and closing it.
➢ MA.3.01 - Determine and use the implicit differentiation and apply this method to solve real-world problems.	➢ Related time rates are an application of the implicit differentiation. It is based on forming a relation between givens and taking derivative with respect to time (t) for these givens. We used this concept in calculating the time rate of which the chamber is purified from toxic (CO) and of which the gases are leaked. We could do this process by taking derivative for the volume of the cube chamber that is V=L3, where (L) is the side length of cube, then dV/dt=3L2× (dL/dt), where (dV/dt) is the rate of leakage of the toxic gasses by air purifier (required), (dL/dt) is the rate of shortage of side of the toxic gases volume. At the first, the volume of toxic gases equals to the volume of the chamber (V). Thus, these gases have the same length of the chamber (L). After the air purifier is switched on, the volume of toxic

	gases decreases by rate of (dV/dt). Also, the side (L) decreases by rate of (dL/dt).
➢ CH.3.03 - Students will design and conduct a laboratory investigation to demonstrate the Law of Conservation of Mass.	➢ Stoichiometry is the quantities of materials consumed and produced in chemical reactions. Stoichiometry is founded on the law of conservation of mass, where the total mass of the reactants equals the total mass of the products. It helped us a lot to predict the level of carbon monoxide (CO) gas in air in the chamber after the leakage of methane (CH4) and carbon dioxide (CO2) as they react with each other or (CH4) reacts with water vapor to form (CO) and hydrogen (H2) gas as following: $CH_4 + H_2O \rightleftharpoons CO + 3H_2$ $CH_4 + CO_2 \rightleftharpoons 2CO + 2H_2$
➢ PH 3.03 - Analyze oscillatory motion.	➢ In physics, we have been studying oscillations and simple harmonic motion, which is a repeated motion in which a body repeats the same movement in the period of time. The amplitude of the oscillatory motion is the maximum displacement a spring can move in the X-axis. Furthermore, the frequency is the number of oscillations per second whereas the period is time needed for one oscillation to happen. Our group chose to work on the pollution grand challenge and monitor the leak of CO gas (the problem) in the steel factories and purify it. We benefited from the shape motion of the oscillating liquid droplets in water vapor as it plays a

	significant role affecting the mass transfer between the gas and the liquid droplets, which is an important mechanism for the transportation of gas pollutant species in the atmospheric environment. We made a proper description of the shape motion of droplets to create a model for the use in air quality modeling of the atmospheric environment. We applied simple harmonic motion to describe the variation of the vertical axis of the droplet with successful oscillations. We needed to make calculations to determine the range of the sensor we would use. Firstly, we determined the maximum amplitude of the oscillation of water droplets to be in of water vapor. Next, we used the amplitude concept to calculate the horizontal range of our sensor in the volume which is. We precisely determined the concentration of CO in this volume and chose our sensor range to be from PPM.
➢ PH 3.08 - Describe how information can be transmitted via electromagnetic radiation.	➢ Wi-Fi modules transmit data through air in form of a high-frequency radio waves. We can describe a wave by the factors of the oscillatory motion (K, w, lamda, f, T). This is because the waves describe the motion of a particles on the graph of (y) and (x). The frequency (f) is the crests or troughs in a position (x) per second. For the radio waves, its estimated frequency range is from 104 to 108 Hertz. But, the IoT devices use high

	energy waves to propagate through difficult obstacles, so 108-hertz waves are used. The periodic time is the time between two crests or two troughs along a (y) and a (T) graph. T=1/f, that is equal to T = 10-8. The shape motion of an oscillating falling liquid droplets plays a significant role to affect the mass transfer between gas and liquid droplets, which is an important mechanism for the transport of gas pollutant species in the atmospheric environment such as wet deposition and the air pollution control devices (APCDs) such as wet scrubbers. We could apply the equation of y=Asin(kx-wt) where y is the position of pollutants transferred as an example, A is the amplitude, k is the wave number, x is the position on x axis on graph, w is the angular frequency, and t is the time.
➢ CH.3.02 - Students will apply their understanding of uncertainty of measurement to their own experiments as well as the analysis of others' experimental data.	➢ Precision and accuracy are two terms often used to describe the reliability of measurements. Accuracy refers to the agreement of a value with the true value. Precision refers to the degree of agreement among several measurements of the same quantity. The combination between the two was very useful for us making a test plan, predicting, and understanding the errors of gas sensors. The error of the sensors was ±0.1 from datasheets on the websites. The results of project showed errors in reading CO gas as the readings of CO gas were 50±0.1, 50±0.1, 51±0.1. So, the reading of test plan met the

	expected errors and that make the prototype accurate and precise as the readings matched with the true value and were close to each other at the same time.
➢ CS.3.01 - students demonstrate understanding of the requirements for producing mobile applications.	➢ Mobile application is an application software designed to run on a mobile device, such as a smartphone or tablet computer. Mobile application helps to provide essential services provided by PCs. Mobile applications could be better than desktop software as they provide mobility and easy access. Besides, they might contain more features in certain tasks. The process of making Mobile application is crucial and contains many important steps, such as Identifying the need, laying out features, designing, choosing the program to work on (like android studio). The most important requirement of the app is identifying the target of the app and whom people it will affect. We benefited from it in simulating the workers who will use a mobile application to indicate whether they feel any symptoms. The application will decide on if the symptoms indicate a certain leakage, and the device will then check for that.
➢ CH.3.05 - Students will be able to offer a simple set of observations	➢ Graham's law of effusion (also called Graham's law of diffusion) was formulated to calculate at which a gas leaks from an aperture or diffused throughout a restricted place. It states that the rate of effusion of a

about what they see in the laboratory, write a balanced equation and explain in terms of atoms, molecules, collisions between them and electron interactions	gas is inversely proportional to the square root of the mass of its particles. This formula can be written as: $〖Rate〗_1/〖Rate〗_2 = \sqrt{M_2/M_2}$. (Rate1) is the rate of effusion for the first gas, volume or number of moles per unit time. (Rate2) is the rate of effusion for the second gas. (M1) is the molar mass of gas 1. (M2) is the molar mass of gas 2. We used this law to determine the rate at which the CO, CH4 gases spread throughout the box. We calculated their concentration to be aware which values are in the normal range and which are in the danger range.
➢ EN.3.01 - Maintain neatly organized writing portfolios for use in tracking their growth as maturing writers.	➢ To write in a formal, organized style, one should not specify details to a certain group people, but rather generalize his ideas thoroughly then write the exception of such a case. Formal and informal language serve different purposes. The tone, the choice of words and the way the words are put together vary between the two styles. Formal language is less personal than informal language. It is used when writing for professional or academic purposes like university assignments. Formal stylish texts use a lot of transitions linking words. Also, a formal text should be focused and cohesive throughout the whole the paragraph. One should not write contractions, and should use formal vocabulary. Our portfolio and poster are formal research papers used to describe

	the details of the solution we have chosen for solving our problem. Hence, we used such technics we have learned to write our portfolio and poster. In the discussion, the selection of solution, and the selection of prototype, we used the concepts of persuading essay to convince everyone read our portfolio with the solution we have decided on.
➢ ME.3.03 - Students will be able to analyze Rotational Kinematics of systems for constant and non-constant angular acceleration	➢ Angular motion represents motion in with a constant radius. Every point of a rigid object rotating about a fixed axis moves in a circle whose center is on the axis and whose radius is the radial distance from the axis of rotation to that point. A radius drawn from the rotation axis to any point on the body sweeps out the same angle in the same time. For a body that is rotating at angular position (theta1) at t1 and at (theta2) and t2, we define the instantaneous angular velocity of the body as $\boldsymbol{\omega} = \lim_{t \to 0} \boldsymbol{\omega_{avg}} = \frac{d\theta}{dt}$. We used this concept to calculate the angular velocity at which the fan (air sucker) is rotating to measure the rate at which the CO is coming out of the box. Furthermore, we related the angular velocity of the fan to the voltage by which it is powered. We found that a proper and intermediate voltage to connected the fan on is 5V.

Table (8)