Dead Matter Respiration

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Maadi STEM School for Girl

1st semester

Group No. 11310

Table of Contents:

I. Introduction

II. Present and Justify a Problem and Solution Requirements

- ***A.*** *Egypt grand challenges*
- ***B.*** *Problem to be solved*
- ***C.*** *Research*
- ***D.*** *Other solutions already been tried*

III. Generating and Defending a Solution

- ***A.*** *Solution and design requirements*
- ***B.*** *Selection of solution*
- ***C.*** *Selection of prototype*

IV. Constructing and Testing a Prototype

- ***A.*** *Materials*
- ***B.*** *Methods*
- ***C.*** *Test plan*
- ***D.*** *Data collection*

V. Evaluation, Reflection, Recommendations

- ***A.*** *Analysis and Discussion*
- ***B.*** *Conclusion*
- ***C.*** *Recommendations*
- ***D.*** *Learning Outcomes*
- ***E.*** *List of Sources in APA Format*

Introduction:

Climate change represents a massively serious issue that doesn't only hazard or harshly threaten Egypt but the entire world. According to NASA and many other scientific agencies, climate change has been apparently considered to be the most pressing challenge humanity encounters. Climate change affects all aspects of life, starting from economics, politics, education, and health to tourism, etc; its causes are countless and varied from using fossil fuels to natural phenomena such as matter decomposition and anaerobic respiration. Despite that decomposition provides essential nutrients and is considered mostly to be a beneficial, valuable phenomenon, Carbon Dioxide (CO_2), Methane (CH_4), and other gases released from the decomposed matter play a tremendous role in increasing air temperature and humidity, which, in turn, influences global warming and climate change. A handful of prior solutions regarding decomposition include but are not limited to measuring the impact of decomposed matter in swamps, canals, and even landfills. Two British researchers recognized, using traditional methods and low-tech measuring techniques, the direct relation between decomposition and CO_2 emissions but couldn't accurately identify the impact of decomposition on climate change using a completely accurate technical system. Thus, a demand for high-tech measuring methods was necessary to help establish an accurate relationship between decomposition and climate change.

This project fundamentally identifies the exact relation between decomposition and climate change using a complete IoT system by measuring three design requirements: temperature, humidity, and amount of Carbon Dioxide (CO_2) released. With the help of both digital and analog sensors such as DHT11, which is a digital temperature and humidity sensor, and MQ135, which is an analog CO_2 and CH_4 sensor, accurately-detailed results and relations were concluded to support our project hypothesis. Numerous graphs and figures were designed to depict the relations between multiple variables such as the relation between temperature and time, humidity and time, CO_2 and time, CO_2 and temperature, and CO_2 and humidity. As a result of this thoroughly comprehensive analysis, the design requirements were precisely addressed and displayed on a Graphic User Interface (GUI), an HTML, CSS, and JavaScript website designed from scratch to easily demonstrate data and tests for users.

Present and Justify a Problem and Solution Requirements

I. Egypt grand challenges:

1. Reduce and adapt to the effect of climate change:

Climate change is one of the most serious problems because it leads to many global problems such as melting ice in the poles, which leads to high water levels and drowning some important coastal cities such as Alexandria.

Causes of climate change:

- ❖ Burning coal, oil, and gas produce carbon dioxide and nitrous oxide.
- ❖ Cutting down forests (deforestation). Trees help to regulate the climate by absorbing CO_2 from the atmosphere. So, when they are cut down, that beneficial effect is lost and the carbon stored in the trees is released into the atmosphere, adding to the greenhouse effect.
- ❖ Increasing livestock farming. Cows and sheep produce large amounts of methane when they digest their food.
- ❖ Fertilizers containing nitrogen produce nitrous oxide emissions.
- ❖ Fluorinated gases produce a very strong warming effect, up to 23000 times greater than CO_2.

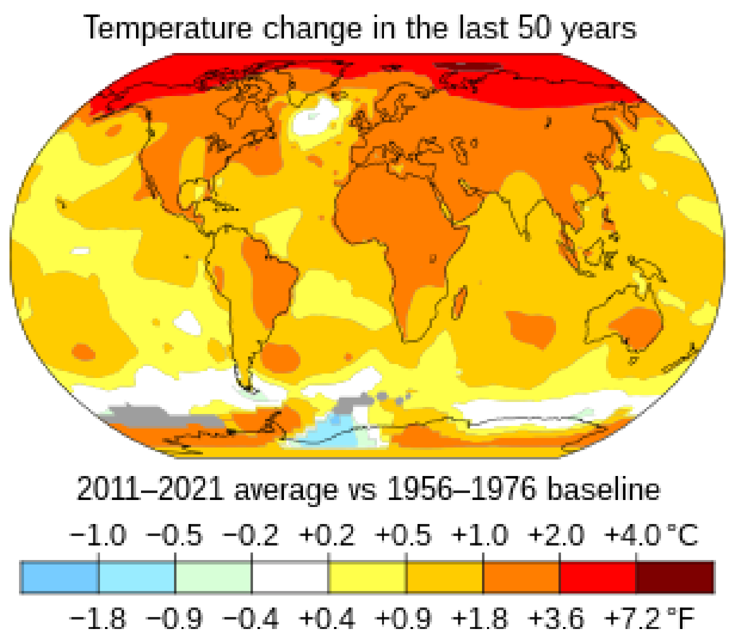


Figure 1

Effects of climate change:

More frequent and intense drought, storms, heat waves, rising sea levels, melting glaciers, and warming oceans can directly harm animals, destroy the places they live, and wreak havoc on people's livelihoods and communities. As climate change worsens, dangerous weather events are becoming more frequent or severe.

Solutions for climate change:

- ❖ Reducing fossil fuels whose combustion increases the percentage of greenhouse gases in the atmosphere, including carbon dioxide.
- ❖ Using automobile exhaust filters and factory nozzles to purify the air leaving them from greenhouse gases.
- ❖ Try to use renewable and permanent energies and reduce the use of permissible energies.

Climate change rates around the world:

Climate change rate has been significantly increased during the last decades and its impacts are affecting every aspect of life. The following figures show statistics regarding climate change in the past few years.

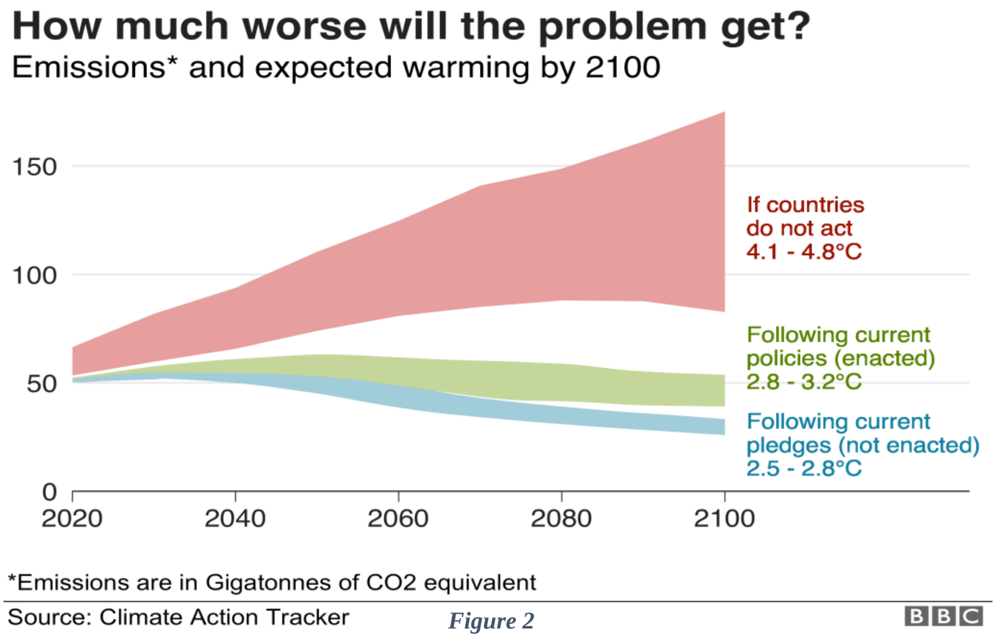


Figure 2

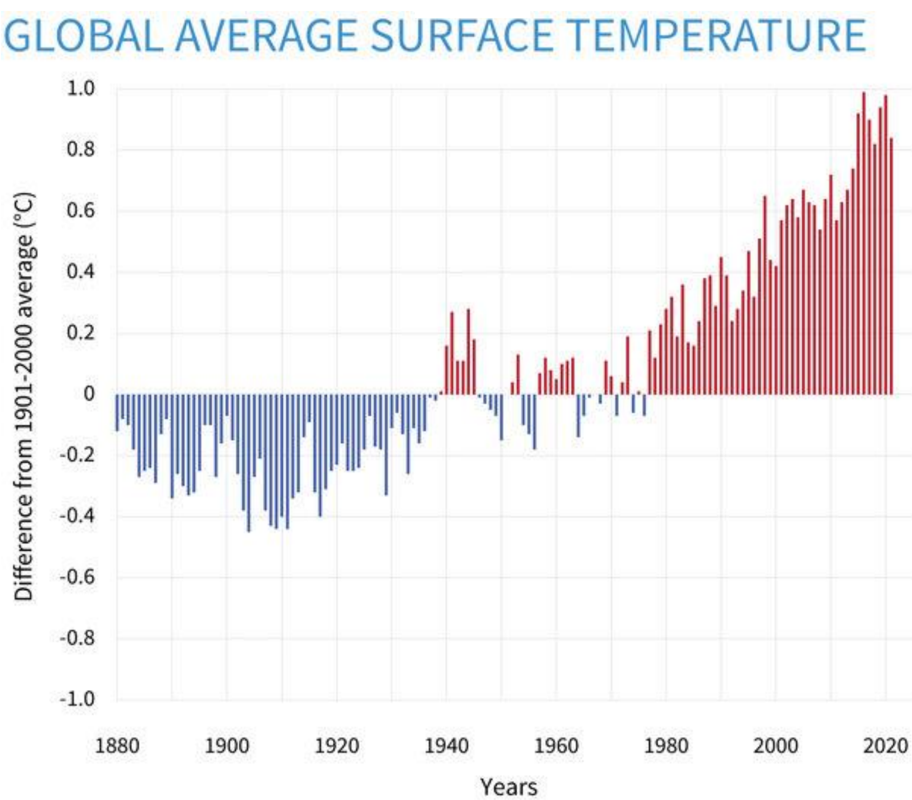


Figure 3

2. Improve the scientific and technological environment for all:

The new technology that increases food production, improves infrastructure, improves healthcare, and provides sanitary facilities has the potential to significantly enhance the quality of life in poor countries.

Service and technology distinguish nations that can successfully reduce poverty by growing and improving their economy from those that cannot. The extent to which emerging nations emerge as economic powerhouses is determined by their capacity to understand and implement scientific and technological ideas, as well as employ them creatively. The fundamental engine of technical advancement and greater living standards is innovation.

Resource-intensive technologies aimed at meeting high consumer demand contribute to increased carbon emissions and environmental harm.

Figure 2

Advantages:

The benefits that are guaranteed to flow from the technology revolution in a more connected and knowledge-intensive world will be taken by those governments and businesses who are aware of the quickly changing environment and flexible enough to seize the chances. Those who succeed will make significant strides in reducing poverty and inequality.

Difficulties:

In developing countries, technology is lacking, which adds to widespread poverty and a lack of necessities such as clean, flowing water and food supply.

Solutions:

To foster technological advancements, developing countries should invest in excellent education for the young, ongoing skill training for employees and management, and ensure that information is spread as broadly as possible across society.

II. Problem to be solved

Climate change represents a significantly serious issue that doesn't only threaten or harshly affect Egypt but the entire world. According to many other scientific agencies, it's evident that climate change is considered to be one of the most pressing challenges that humanity encounters. As a matter of fact, it affects all aspects of life, starting from economics to tourism and almost every other life aspect.

Climate change refers to long-term shifts in temperatures and weather patterns. These shifts may be natural, such as through variations in the solar cycle. But since the 1800s, human activities have been the main driver of climate change, primarily due to burning fossil fuels like coal, oil, and gas.

Examples of greenhouse gas emissions that are causing climate change include carbon dioxide and methane. These come from using gasoline for driving a car or coal for heating a building, for example. Clearing land and forests can also release carbon dioxide. Landfills for garbage are a major source of methane emissions. Energy, industry, transport, buildings, agriculture, and land use are among the main emitters.

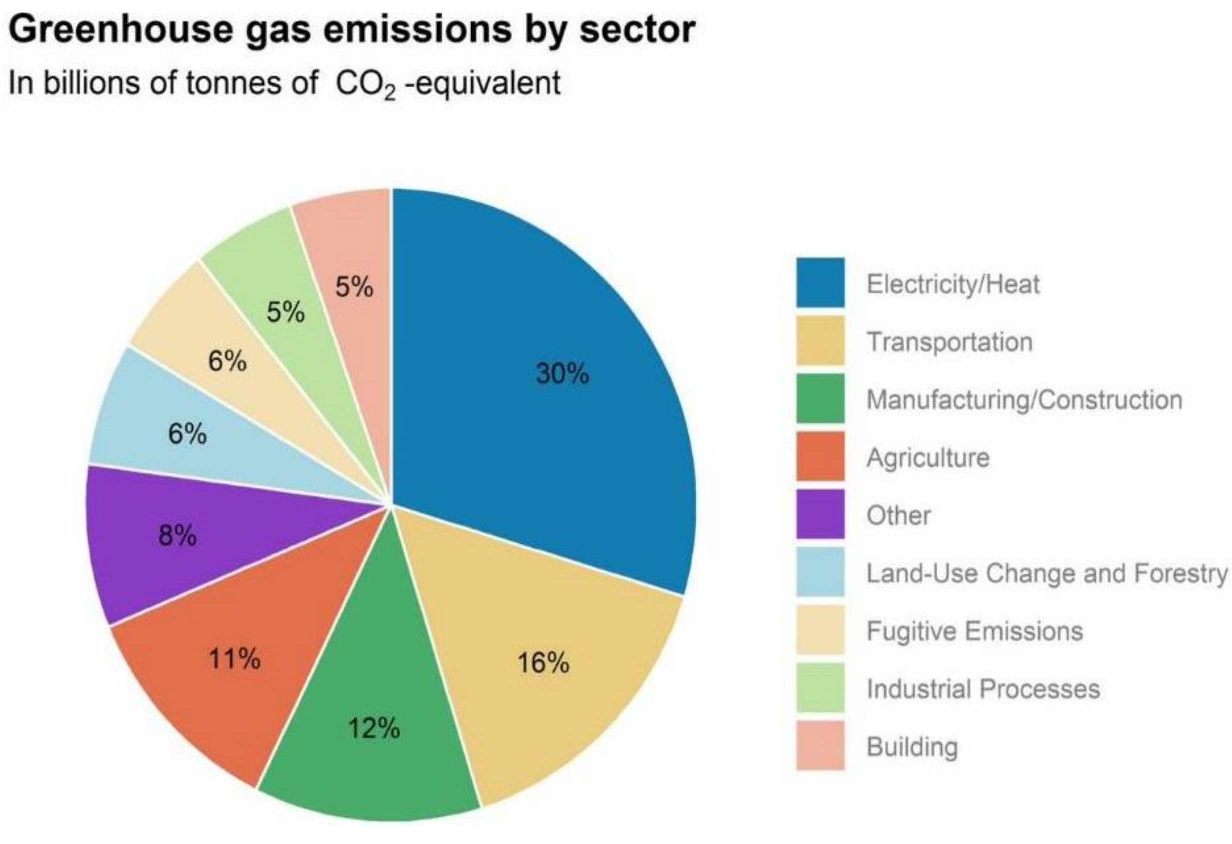


Figure 3

It's crucial to understand that climate change is not a future problem. "Changes to Earth's climate driven by increased human emissions of heat-trapping greenhouse gases are already having widespread effects on the environment: glaciers and ice sheets are shrinking, river and lake ice is breaking up earlier, plant and animal geographic ranges are shifting, and plants and trees are blooming sooner. Effects that scientists had long predicted would result from global climate change are now occurring, such as sea ice loss, accelerated sea level rise, and longer, more intense heat waves. The following graph depicts various causes of climate change:

It's significant that governments quickly take an action against climate change to help overcome its negative consequences. The following table and figure demonstrate both the positive and negative impacts of climate change if climate change will not be solved.

Table 1

Positive Impacts	***Negative Impacts***
Helping avoid the runaway costs of climate change Creating jobs Competing internationally Improving public health Saving households and businesses money Enhancing national and global security Providing benefits to farmers Delivering benefits to low-income households Preserving vital ecosystems and species Conserving water resources and clean water	Hotter temperatures More severe storms Increased drought A warming, rising oceans Loss of species Not enough food More health risks Poverty and displacement

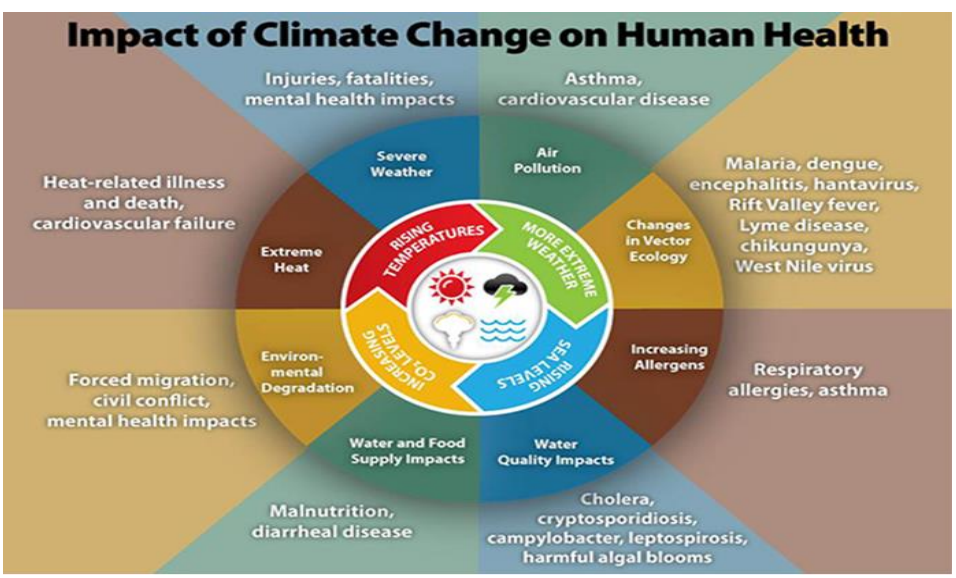


Figure 6

III. Research

Topics related to the problem:

- ### Hotter temperatures

As greenhouse gas concentrations rise, so does the global surface temperature. The last decade, 2011-2020, is the warmest on record. Since the 1980s, each decade has been warmer than the previous one. Nearly all land areas are seeing more hot days and heat waves. Higher temperatures increase heat-related illnesses and make working outdoors more difficult. Temperatures in the Arctic have warmed at least twice as fast as the global average.

- ### Warming, rising ocean

The ocean soaks up most of the heat from global warming. The rate at which the ocean is warming has strongly increased over the past two decades, across all depths of the ocean. As the ocean warms, its volume increases since water expands as it gets warmer. Melting ice sheets also cause sea levels to rise, threatening coastal and island communities. In addition, the ocean absorbs carbon dioxide, keeping it from the atmosphere. But more carbon dioxide makes the ocean more acidic, which endangers marine life and coral reefs.

- ### Species extinction

Climate change poses risks to the survival of species on land and in the ocean. These risks increase as temperatures climb. Exacerbated by climate change, the world is losing species at a rate 1,000 times greater than at any other time in recorded human history. One million species are at risk of becoming extinct within the next few decades. Forest fires, extreme weather, and invasive pests and diseases are among many threats related to climate change. Some species will be able to relocate and survive, but others will not.

- ### More health risks

Climate change is the single biggest health threat facing humanity. Climate impacts are already harming health, through air pollution, disease, extreme weather events, forced displacement, pressures on mental health, and increased hunger and poor nutrition in places where people cannot grow or find sufficient food. Every year, environmental factors take the lives of around 13 million people. Changing weather patterns are expanding diseases, and extreme weather events increase deaths and make it difficult for healthcare systems to keep up.

Topics related to the solution:

- **Decomposition**

Decomposition literally means "to break down." Typically, it refers to the breakdown or rupture of a complex organic matter into a simpler inorganic substance. It is a vital component of the ecosystem's processes. Decomposition is therefore a metabolic process that consumes complex chemicals as raw materials, processes them, and then transforms them into simpler ones. Decomposers, which include bacteria, fungi, and a few other microorganisms, are those who start the decomposition process. To stay alive, they consume dead creatures. Dead and decaying animals and plants are used as the raw materials for the breakdown of which nutrients, carbon dioxide, and water are produced.

- **Anaerobic respiration**

Simply, Anaerobic Respiration can be defined as the cellular respiration process occurring in an anoxic environment in the absence of oxygen. Anaerobic Respiration is the respiration process where the terminal electrons released during oxidation-reduction of nutrients are transferred to several organic and inorganic electron acceptors other than oxygen molecules to produce the energy molecule ATP. Anaerobic respiration primarily takes place in the cytoplasm, in contrast to aerobic respiration, which happens in both the cytoplasm and mitochondria. Anaerobic glycolysis takes place first, followed by fermentation. Either organic acids (lactic acid) or molecules of ethanol and ATP are the final products (energy).

- ### IoT (Internet of Things)

An IoT ecosystem consists of web-enabled smart devices that use embedded systems, such as 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.

IV. Other solutions already tried

a. DAC (direct air capture)

The most recent report, published by the Intergovernmental Panel on Climate Change in August, revealed that our excess carbon dioxide emissions have resulted in a 1.1-degree Celsius increase in temperatures since preindustrial times. Scientists say temperatures will continue to rise as carbon dioxide levels increase, resulting in more extreme weather events, heat, drought, and a catastrophic decline in biodiversity. So, DAC may solve this problem.

DAC (direct air capture):

DAC machine has to carry out -- taking in millions and millions of particles of air and sifting through them to grab carbon dioxide. To do so, DAC facilities use a series of huge fans to suck in ambient air and push it through a filter laced with chemicals that carbon dioxide reacts with and sticks to. Think of it as a specialized kind of flypaper. The CO2 gets trapped, while the other components of air pass right through. Heat, pressure, or other chemicals can unstick the concentrated carbon dioxide. You could squirrel away this stock of CO2 underground, mix it with water and inject it into the Earth where it mineralizes and turns to stone. You've just removed CO2 from the atmosphere. The following figure shows the mechanism of the system.

But since carbon dioxide makes up such a tiny fraction of the air we breathe, DAC facilities need to take a whole lot in. This requires energy. The heating of the filter to free the concentrated CO2 also requires energy. If that energy is provided by fossil fuels, well… you can see the conundrum. There are 19 direct air capture facilities in operation around the world, according to the International Energy Agency. Fifteen of these are operated by Swiss company Clime works, and its most recent DAC facility highlights both the promise of vacuuming up CO2 and the remaining hurdles to large-scale builds.

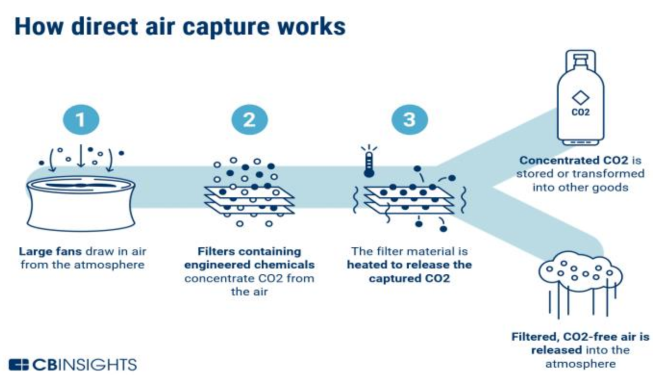


Figure 4

1. DAC Reduces Atmospheric CO2
2. DAC Requires a Smaller Footprint
3. DAC Can Achieve Net-Zero or Negative Emissions

Disadvantages:

1. DAC Requires Large Amounts of energy
2. It's Currently Very Expensive
3. It has some environmental Risks

b. *Grove 101020067:*

Looking at CO2 levels from 1950 to the present it is clear that CO2 levels are significantly higher than ever before and it is strongly suspected that we are living in the grace period of the lag time before global temperatures begin to soar.

Sensor solution:

the Grove 101020067 from Seed Technologies. It is a high-sensitivity, high-resolution (1 ppm resolution at 0-2000 ppm range) device that uses non-dispersive IR technology to measure airborne levels of carbon dioxide through varying humidity levels (from 0% to 90% relative humidity). Integrated temperature sensors allow the Grove sensor to compensate for temperature variations, and the simple UART output is easy to interface to virtually any microcontroller-based system.

Figure 5

Advantages:

1- High sensitivity.
2- High resolution
3- Easy to use

Disadvantages:

1. high cost

c. *Rice Farmers Use IoT to Save Water and Carbon Emissions:*

In general, rice cultivation is known to be a major emitter of greenhouse gases, especially methane (CH4), due to the overly excessive rate of rice plantation that requires huge amounts of water. The following figure depicts how rice plantation affects global warming, which, in turn, affects climate change.

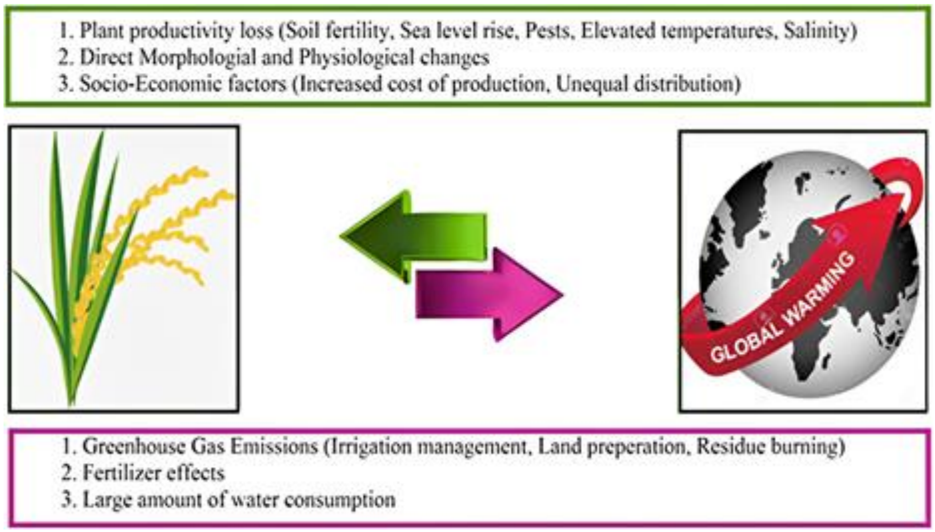


Figure 6

Being aware of the significant negative impacts that planting rice could have on the environment and climate change, farmers in Arkansas, a small US state, were concerned with lowering the effects of planting rice on their community. Recognizing the significant amount of CH4 that is released from wet rice lands, it can be concluded that rice plantation is one of the major reasons for the highly increased rate of CH4 emissions and, in turn, climate change. The following graph demonstrates how the increasingly high rice rate affects climate change in different regions of the world.

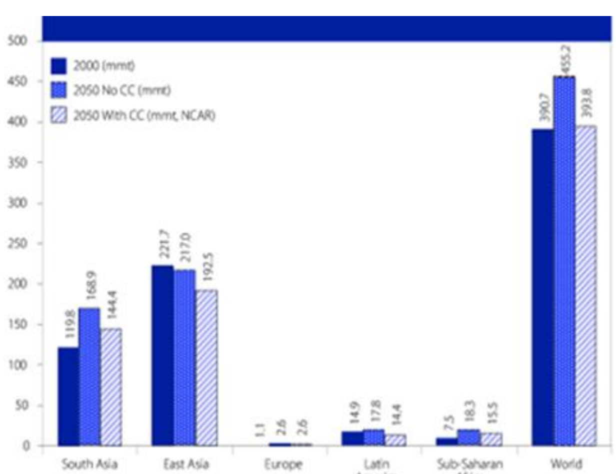


Figure 7

“Alternate Wetting and Drying” (AWD) is a method of rice farming that addresses many of these environmental challenges. Instead of keeping a constant four-inch flood, AWD allows fields to dry down between floods after establishing the initial flood. By decreasing the number of times fields remain flooded, AWD reduces water use, fuel and electricity use for running irrigation pumps, and the need for nitrogen fertilizers, while also slowing down the anaerobic activity that creates methane gas. Farmers and researchers are working together to optimize AWD and have found that when implemented properly, the practice can potentially increase yields while reducing fertilizer and water inputs as well as GHG emissions. However, AWD can be challenging. It requires farmers to control water levels carefully across large tracts of land. It also introduces risk to the rice crops, as it can be difficult to assess depth accurately with only a few measurements at various points in the fields. Together, these barriers have slowed the adoption of AWD.

The use of IoT:

“Using AT&T’s IoT solutions to connect water-level sensors and pumps can increase the control farmers have over their operations, helping to drive efficiencies and overcome some of the barriers to AWD adoption. Using specific sensors that could read water levels once an hour to allow for 24-hour monitoring, while the Pumping remote monitors allow farmers to set customized parameters for remotely turning pumps on and off. Consequently, farmers will be able to lower the amount of water used, which will result in lowering the number of wetlands which will decrease CH4 emissions”. By implementing this project, the amount of CH4 released for rice plantation will significantly decrease, which, in turn, will narrow the effect of climate change.

Generating and Defending a Solution

I. Solution and design requirements

Solution requirements:

A. **Eco-friendly:** No harmful emissions or by-products must result from the decomposition process.

B. **Low cost:** The sensors have to be reasonably priced to be widely available.

C. **Reproducibility:** it is the extent to which repeating an experiment yields consistent results. This can be represented in the capability of the sensors to reprocess the error in the product.

D. **The sensor's resolution:** resolution is defined as the smallest amount of change in the input that can be detected and reliably expressed.

E. **Simplicity:** the sensors must be accessible and simple to get.

Design requirements:

The following three criteria were chosen to be the main design requirements; the amount of marsh gas, all of which are concerned with measuring the number of gases produced and their effects on climate change.

1. Marsh gases:

Marsh gases, also known as swamp gas or bog gas, is a mixture primarily of methane and smaller amounts of hydrogen sulfide, carbon dioxide, and trace phosphine that is produced naturally within some geographical marshes, swamps, and bogs. Marsh gas is produced by the anaerobic bacterial decomposition of vegetable matter and the rumen of herbivorous animals underwater.

As methane and carbon dioxide are the major gases that negatively affect climate change, so we will use a sensor that detects both of them which is called an MQ2 sensor.

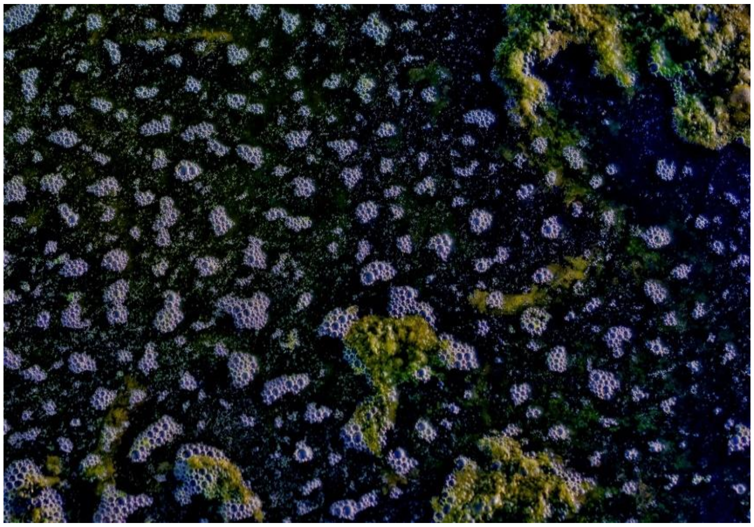


Figure 8

MQ2 gas sensor is an electronic sensor used for sensing the concentration of gases in the air such as LPG, propane, methane, hydrogen, alcohol, smoke, and carbon dioxide. It is also known as a chemiresistor. It contains a sensing material whose resistance changes when it comes in contact with the gas. This change in the value of resistance is used for the detection of gas.

2. Temperature

The global surface temperature rises together with greenhouse gas concentrations such as CO2 and CH4. Every decade since the 1980s has been warmer than the one before it. There are more hot days and heat waves in almost all geographical locations. Higher temperatures exacerbate heat-related ailments and make it more challenging to work outside.

As the decomposition of organic matter increases the temperature increases and also temperature is one of the most crucial factors that contribute to increasing the decomposition rate.

The sensor that measures the temperature is called DHT22. The DHT22 is a commonly used Temperature and humidity sensor. The sensor comes with a dedicated NTC to measure temperature and an 8-bit microcontroller to output the values of temperature. The sensor is also factory calibrated and hence easy to interface with other microcontrollers. The sensor can measure temperature from -40°C to 80°C with an accuracy of ±1°C.

3. Humidity

Carbon dioxide and water are the results of anaerobic respiration. So as a result of the breakdown process, the amount of water vapor in the air increases, increasing humidity.

The humidity sensor is a differential capacitance type that consists of a layer sensitive to water vapor that is sandwiched between two electrodes that act as capacitor plates. The upper electrode consists of a grid that allows water vapor to pass into the sensitive layer, thus altering the capacitance between the two electrodes. The sensor that measures the humidity is called DHT22. The humidity range is from 0% to 100%. The humidity sensor resolution both are 16-bit.

II. Selection of solution

The selected solution consists of two phases:

- ✓ The first phase is the creation of a simulation of the anaerobic decay by making a decomposition process of organic matter.
- ✓ The second phase is constructing the IoT system and analyzing the results in a GUI (Graphic User Interface).

The selection of solution process:

- ❖ The simulation process requires an organic matter which is decomposed to simulate anaerobic respiration. The organic matter that was chosen is the bread because bread mold fungus relies on anaerobic respiration to release lactic acid, carbon dioxide, methane, and water which are regarded as marsh gases that have harmful effects on the climate.
- ❖ After selecting the source of organic matter, it will be put inside a container whose volume is about (4500 cm^3) then, put the two sensors which are DHT11 that measure the temperature and humidity and Mq135 that measure the marsh gases and leave it about 2 to 3 weeks until it completely decomposes.

IoT system:

- ❖ The construction of the IoT system is a collective network of connected devices and the technology that facilitates communication between devices. Every IoT system is made up of sensors/devices, connectivity, data processing, and a user interface.
- ❖ The sensors that are used in the prototype are the temperature and humidity sensor DHT11. It was chosen because it has a temperature measuring range of *0 to +50* degrees Celsius with *+-2.0* degrees accuracy giving us a measuring range suitable for the data and high accuracy.
- ❖ Additionally, another sensor was chosen for our prototype: the air quality sensor MQ135. It was selected because of the prototype's high sensitivity and quick response time.
- ❖ The two sensors are connected with Esp8266 which is a Wi-Fi module microcontroller that gives access to your Wi-Fi network.
- ❖ The connectivity of our system is a device to Cloud because the sensors connect directly to an Internet cloud service with existing Wi-Fi connections and the IP network to exchange data and control message traffic.
- ❖ Lastly, the GUI is a website that shows and analysis the data.

By selecting the most suitable materials, an effective solution will form, hence the problem of climate change will approach to be solved, because the most important thing than solving the problem is identifying and analyzing it to find out the most suitable solution, and this is exactly what our challenge is focused on, and by constructing our prototype we will succeed in achieving our challenge and also solve one of the most Egypt’s disastrous challenges.

III. Selection of prototype

For the sake of implementing and solving this year's capstone challenge, our prototype will consist of the following parts:

1. *Hardware part*

The hardware part of the prototype will be as the following: A plastic container that has a decomposed material inside. For our case, bread mold is chosen to represent the decomposed material. Inside the container, the entire IoT system will be placed on the top of the container to measure the humidity and temperature in addition to the march gases.

2. *IoT part*

This part will consist of an *ESP 6266 NodeMCU* board and two sensors: *DHT11* sensor to measure the humidity and temperature and *MQ135* sensor to measure the *CO2* and *CH4*. Additionally, the *ESP 8266 board* will be connected to a *LCD* to display the collected data from the sensors. Both the *MQ135* and *DHT11* sensors will be connected to a buzzer that will alarm users in certain conditions. The *LCD* is connected to a potentiometer to control the brightness of the *LCD* with the help of internal resistance.

Afterwards, the entire system will be connected to WIFI through an online IoT platform *"Firebase"* which is, then, connected to a Graphic User Interface, a website developed using *HTML*, *CSS*, *JavaScript*, and *PhP*. The following image shows a comprehensive description of how the system will look like.

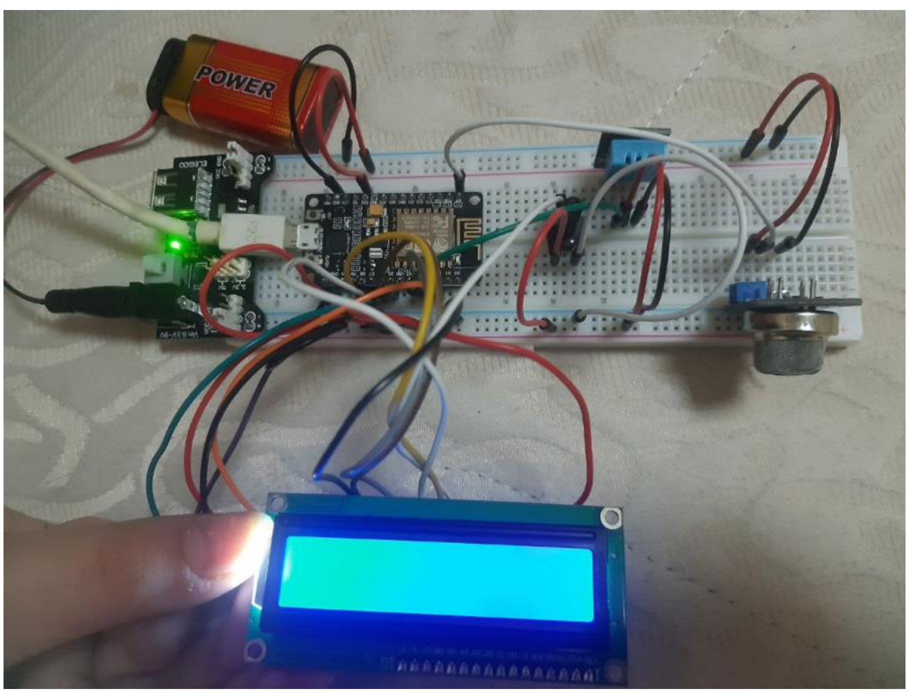


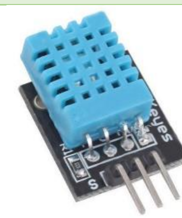
Figure 9

Constructing and Testing a Prototype

I. Materials and methods:

Materials:

Table 2

Item	Quantity	Description	Cost	Usage	Source	Picture
Esp8266 NodeMCU board	1	The ESP8266 Wi-Fi Module is a self-contained SOC with an integrated TCP/IP protocol stack that can give any microcontroller access to your Wi-Fi network.	170.00 LE	Connect the hardware to a wi-fi network	RAM electronics	 *Figure 10*
DHT11 temperature and humidity sensor	1	ultra-low-cost digital temperature and humidity sensor.	35.00 LE	Measure humidity and temperature values in heating, ventilation, and air conditioning systems.	RAM electronics	 *Figure 14*
MQ135	1	Air quality sensor	70.00 LE	Measure the concentration of marsh gases (CO_2- methane)	RAM electronics	 *Figure 12*
Breadboard	1	consists of a plastic block holding a matrix of electrical sockets of a size suitable for gripping thin connecting wires, component wires, or the pins of transistors and integrated circuits (ICs).	60.00 LE	insert electronic components to prototype (meaning to build and test an early version of) an electronic circuit	RAM electronics	 *Figure 13*

LCD	1	A type of flat panel display which uses liquid crystals in its primary form of operation.	74.00 LE	Display data collected from the sensors	RAM electronics	 *Figure 14*
Potentiometer	1	A three-terminal resistor with a sliding or rotating contact that forms an adjustable voltage divider.	20.00 LE	Control the brightness of the LCD using resistance	RAM electronics	 *Figure 15*
Buzzer	1	An audio signaling device, which may be mechanical, electromechanical, or piezoelectric	5.00 LE	Alarm users in certain conditions	RAM electronics	 *Figure 16*
MB102 Breadboard	1	Power Supply Module 3.3V/5V securely fits in a standard 400 or 800.	55.00 LE	Used to connect the power source with the breadboard	RAM electronics	 *Figure 17*
Jumper wires Kit (male-male) & (male-female)	1	A jump wire is an electrical wire, or a group of them in a cable, with a connector or pin at each end.	40.00 L.E	connects remote electric circuits used for printed circuit boards.	RAM electronics	 *Figure 18*
Container	1	Closed Plastic container	45.00 L.E	Packages the materials, where the decomposition takes place.	Amazon	 *Figure 19*

Battery 9V	1	a device that stores chemical energy and converts it to electrical energy.	20.00 L.E	The power source of the sensors	Amazon	 *Figure 20*
Battery cap	1	Battery cap for 9 v Battery	3.00 L. E	shields and protects the battery contacts from coming in contact with other conductors.	RAM electronics	 *Figure 21*
Bread packet	1	Any bread that can be easily decomposed	20.00 LE	White bread	Supermarket	 *Figure 22*

Methods:

Table (3)

(1)	(2)	(3)	(4)	(5)
A container that is tightly closed to prevent any leakage of gases	The MQ135 and DHT11 sensors are stuck on the cover of the container by silicon to be able to measure the emitted gases from the decomposition process.	A slice of bread is placed inside the container (as a source of organic matter), then some water was sprinkled on it.	Leave the bread in the container for about 7 days in a warm place until the bread mold fungus starts to appear.	Observe the change in the reading of the two sensors.

Software:

The following section demonstrates the software part of the prototype which can be accessed through this link: https://github.com/Farahelsadany11/Dead-Matter-Respiration

Digital Sensors:

DHT11 (3pins) → Used to measure temperature and humidity.
Pin connections:
VCC → 3.3 V
GND → GND
Signal pin → D4

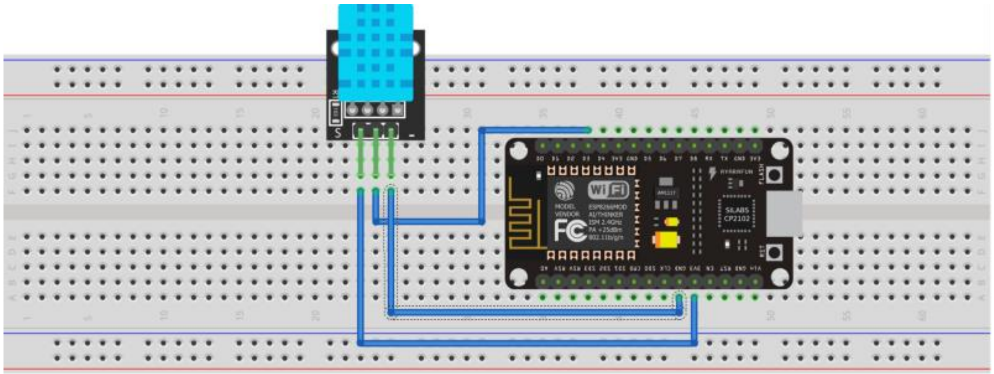


Figure 23

DHT11 Code:

```
DHT dht(DHTPIN, DHTTYPE);

#define DHT11_PIN D4

void setup(){
  Serial.begin(9600);
  dht.begin();
}

void loop(){
  float t = dht.readTemperature();
  float h = dht.readHumidity();

  Serial.print("Temperature = ");
  Serial.print(t);
  Serial.print(" *C ");

  Serial.print("Humidity = ");
  Serial.print(h);
  Serial.println(" % ");
  delay(1000);
}
```

MQ135(4 pins)→ used to measure CO_2 and CH_4 concentration in PPM

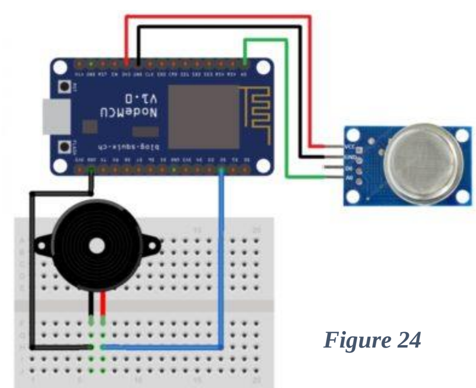


Figure 24

Connections:

VCC→ 3.3 V

GND → GND

AOUT →A0

MQ135 Code:

```
#include <Adafruit_Sensor.h>
void setup(){
  Serial.begin(9600);
}

void loop(){
  int sensorValue = analogRead(A0);
  Serial.println("The amount of CO2 (in PPM): ");
  Serial.println(sensorValue);
  delay(2000);
}
```

ESP8266 board NodMCU → Used to connect the sensors to the Wifi
LCD → Used to display data collected from the sensors

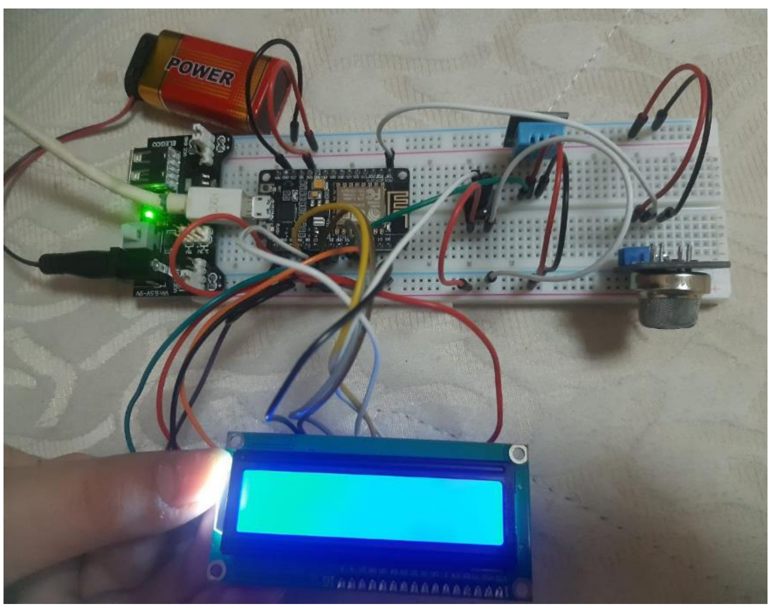


Figure 26

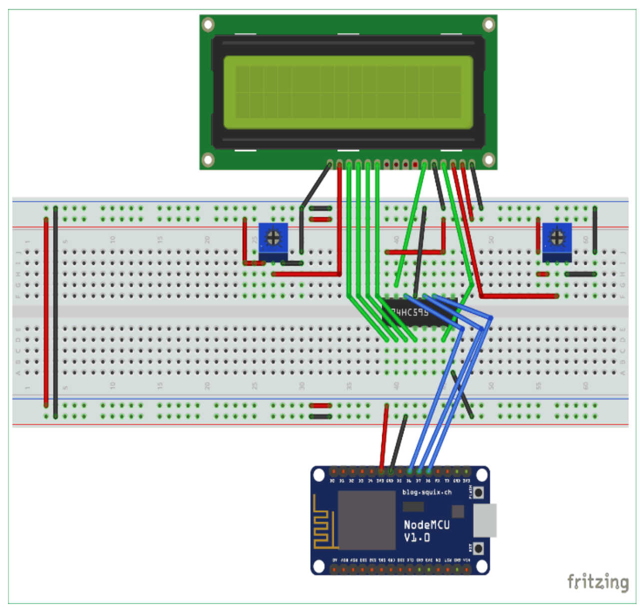


Figure 25

Firebase (IoT platform) → connect the ESP 8266 board with the Graphic User Interface

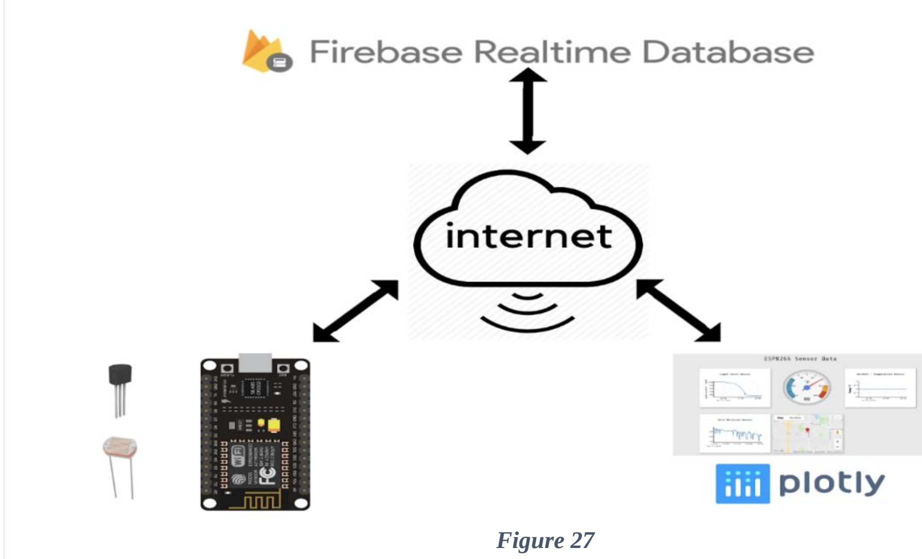


Figure 27

Graphic User interface (GUI)→ A website developed using HTML, CSS, and JavaScript

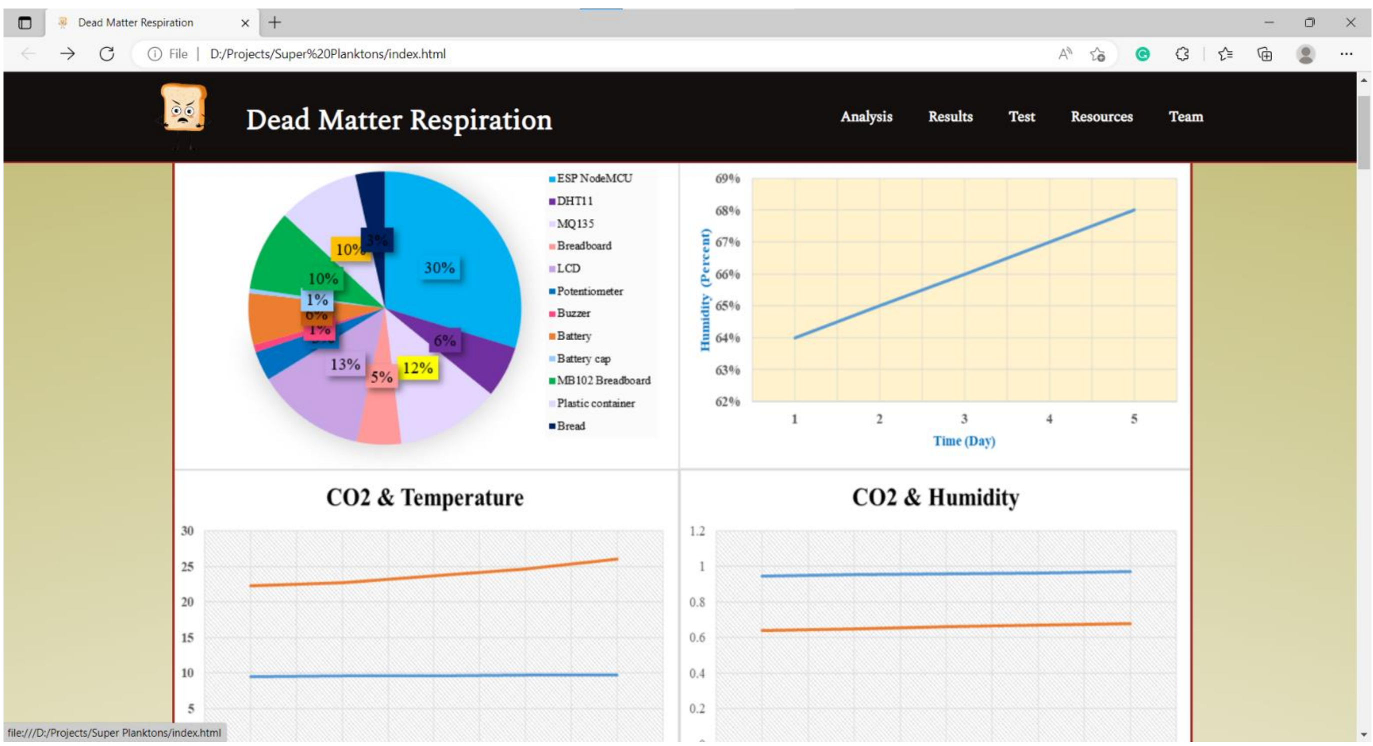


Figure 28

II. Test plan

The design requirements that were tested:

- **The amount of the marsh gases →** It was tested by using an MQ135 air quality sensor.
- **Temperature →** It was tested by using the DHT11 temperature sensor.
- **Humidity →** It was tested by using a DHT11 humidity sensor.

The following steps were taken to conduct the tests:

1. Prepare a large container and fill it with some loaves of bread. To speed up the decomposition process, add a few drops of water.
2. Attach the ESP and sensors to the top of the container

Figure 29

3. During five days, measure the design requirements every day.
4. watching for the data to show up in the GUI.

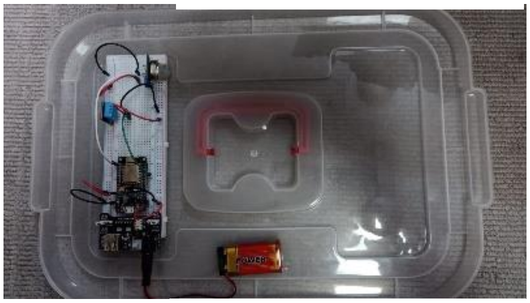


Figure 30

5. Analyze the data, observe how the variables relate to one another, and then illustrate the graphs that demonstrate this relationship.

Figure 31

Figure 32

Safety and Precautions:

Some safety rules were crucial to avoid risks that might face us such as the following:

- Wearing waterproof aprons while testing the prototype to prevent any liquids that may pollute our clothes and avoid being wet.

Figure 33

- Wearing eye goggles to protect eyes from volatile substances like gases and fungus.

- Wearing latex gloves to protect hands from materials that might be toxic such as bread mold fungus.

Figure 36

- Wearing masks to avoid the infection of coronavirus (COVID-19 VIRUS) during our offline meetings.

Figure 35

Figure 34

- Keep electrical appliances and tools away from water.

- Unplug appliances and materials when not in use.

- Never run cords under carpets, rugs, doors, or windows.

The first test:

- The steps of the test were exactly followed as they were described.
- The results of the marsh gases, humidity, and temperature were collected, which were all within an average of 934.2 ppm, 62.19%, and 21.08 °C, respectively.
- When analyzing data, we noticed that the container had small holes that allowed gases to leak out.
- As a result, a decision was made to conduct a second test in a tightly closed container.

The second test:

- The second test was conducted using the identical procedures, although there were some variations.
- An air quality sensor Mq135 was used instead of Mq2 because the tested gases did not produce the expected relationships between temperature, humidity, and CO_2 and their effects on climate change so, in order to measure the gases produced by our phenomena, such as CO_2, methane, and others that have a greater impact on climate change, a Mq135 air quality sensor was employed
- The average results of the temperature, humidity, and marsh gases are 25.04 °C, 67.59%, and 966.4 ppm.

The third test:

- Repeating the previously mentioned processes, the average temperature is 25.38°C, the average humidity is 69.08%, and the average concentration of marsh gases is 973.8 ppm.
- The study showed a direct relationship between temperature and humidity as well as between temperature and marsh gases.

III. Data collection

Average Noise ratio:

- **DH11 temperature and humidity sensor:**

It is used to measure the temperature in Celsius with an error of ***(±2.00 C).***
It is also used to measure the humidity percentage with an error of ***(±5%)***

- **Mq135 air quality sensor:**

It is used to measure the concentration of the marsh gases with an error of ***(±50 PPM).***

Table (4)

I. Temperature

Time	Day 1	Day 2	Day 3	Day 4	Day 5
Trial 1	20.07 °C	20.09 °C	21.20 °C	21.28 °C	22.80 °C
Trial 2	23.01 °C	24.07 °C	24.80 °C	26.03 °C	27.30 °C
Trial 3	23.03 °C	24.00 °C	25.09 °C	26.80 °C	28.00 °C
Average	**22.24°C**±2.0	**22.72°C**±2.0	**23.69°C**±2.0	**24.63°C**±2.0	**26.03°C**±2.0

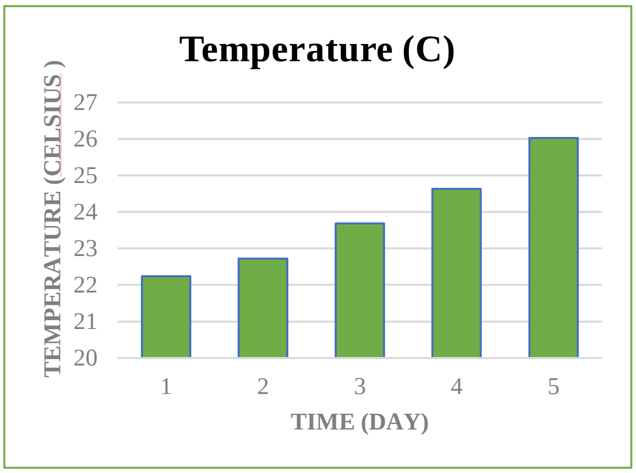


Table (5)

II. Humidity

Time	Day 1	Day 2	Day 3	Day 4	Day 5
Trial 1	60.02 %	62.08 %	62.20 %	63.30 %	63.32%
Trial 2	65.05 %	66.04%	67.2%	69.6%	70.08%
Trial 3	66.01%	68.03%	68.06%	71.3%	72.04%
Average	**64%**±5%	**65%**±5%	**66%**±5%	**67%**±5%	**68%**±5%

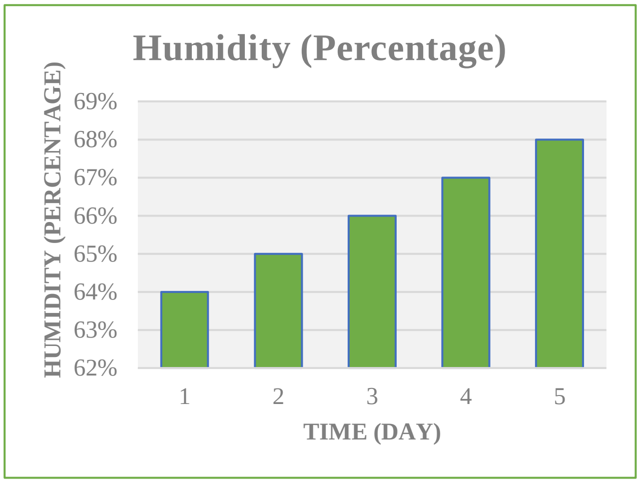
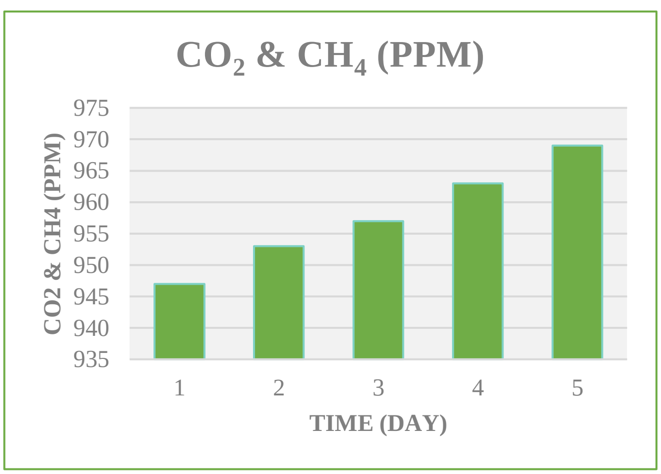


Table (6)

III. March gases

\	Day 1	Day 2	Day 3	Day 4	Day 5
Trial 1	932 ppm	932 ppm	935 ppm	935ppm	937 ppm
Trial 2	950 ppm	960 ppm	966 ppm	976 ppm	980 ppm
Trial 3	960 ppm	967 ppm	972 ppm	980 ppm	990 ppm
Average	**947 ppm** ±50	**953 ppm** ±50	**957 ppm** ±50	**963 ppm** ±50	**969 ppm** ±50



Evaluation, Reflection, Recommendations

I. Analysis and Discussion

Implementing the prototype, some positive and negative results were vividly gathered to determine both the efficiency and effectiveness. Our designed prototype will come in handy with the process of detecting the natural, global phenomenon of decomposition and its effects on climate change which, in turn, will help overcome and precisely address Egypt's climate change-related grand challenges.

Testing analysis:

Table (7)

The following table depicts an analysis of all the tests performed along the testing journey:

Trial Number	***Analysis***	***Modification***
First	• The observations conducted, all the results approximately, remain constant, so we concluded that there is a leakage in the container, as a result of that we conducted a new test with the Airtight container to prevent any leak of gases. • At first, we used an MQ2 air quality sensor that measures propane, methane, carbon monoxide, and some other gases. The tested gases didn't produce the desired relations between temperature, humidity, and CO_2 and their effects on climate change. Thus, we replaced MQ2 with Mq135 which measures CO_2, methane, etc which have more effect on climate change.	• Using a plastic airtight container instead of a glass container. • Using air quality sensor Mq135 instead of Mq2.
Second	• We remarked that the duration of the decomposition process takes about 6 to 7 days, which is relatively more time than expected; hence, we added some drops of water to the bread to increase the decomposition rate. • We used ThingSpeak cloud as an IoT analytics platform, but we discovered that ThingSpeak delays readings of the sensors; thus, we replaced it with Firebase Cloud, which just transfers the data from the sensors to the website.	• Add some drops of water to the bread to increase the decomposition rate. • Using Firebase cloud instead of ThingSpeak

Third	• In comparison to earlier tests, the results from the latest test were more accurate. The rate of temperature increase was noticeable, and it also demonstrates a direct relation between humidity and temperature as well as between marsh gases and humidity. • Finally, we concluded that when the decomposition rate increases, the temperatures rise, and CO2 and other marsh gases as well as humidity levels rise, the climate in Egypt would be significantly impacted in the far future, creating a major problem that needs to be solved right away.	

Analysis Graphs:

The following graphs depict the relations between the tested variables or design requirements, which are as the following:

- A directly proportional relation between Humidity and time; As time increases, humidity increases.

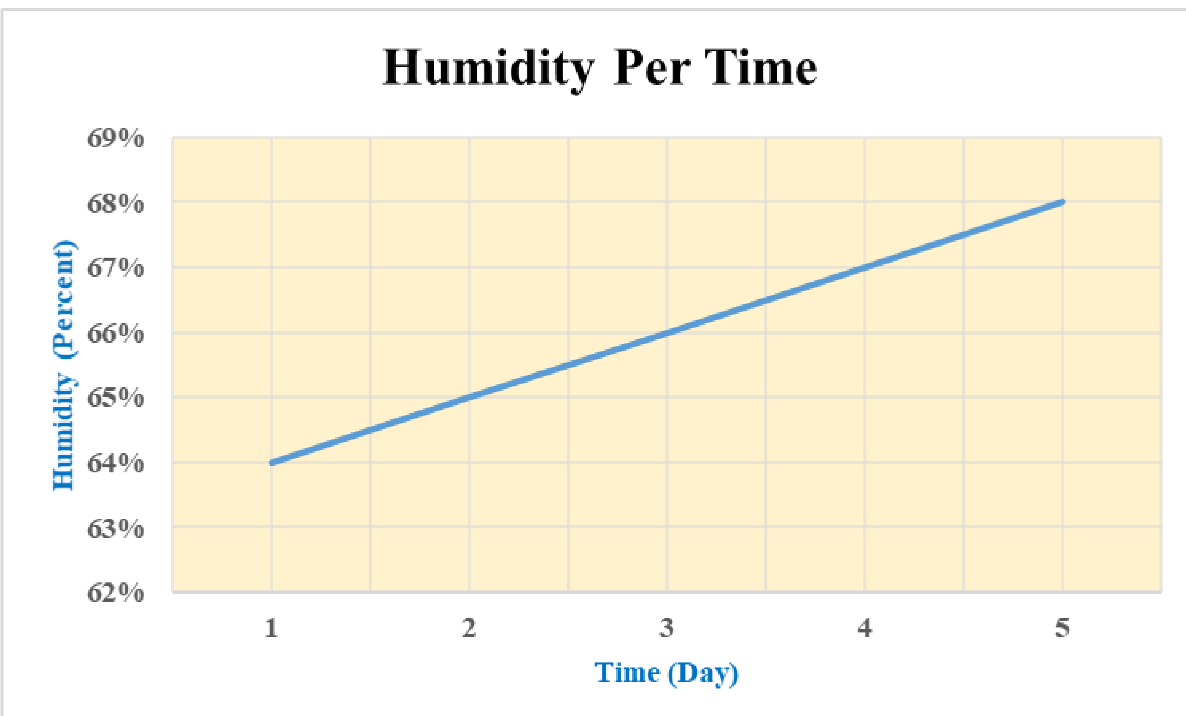


Figure 37

- A directly proportional relation between temperature and time; As time increases, temperature increases.

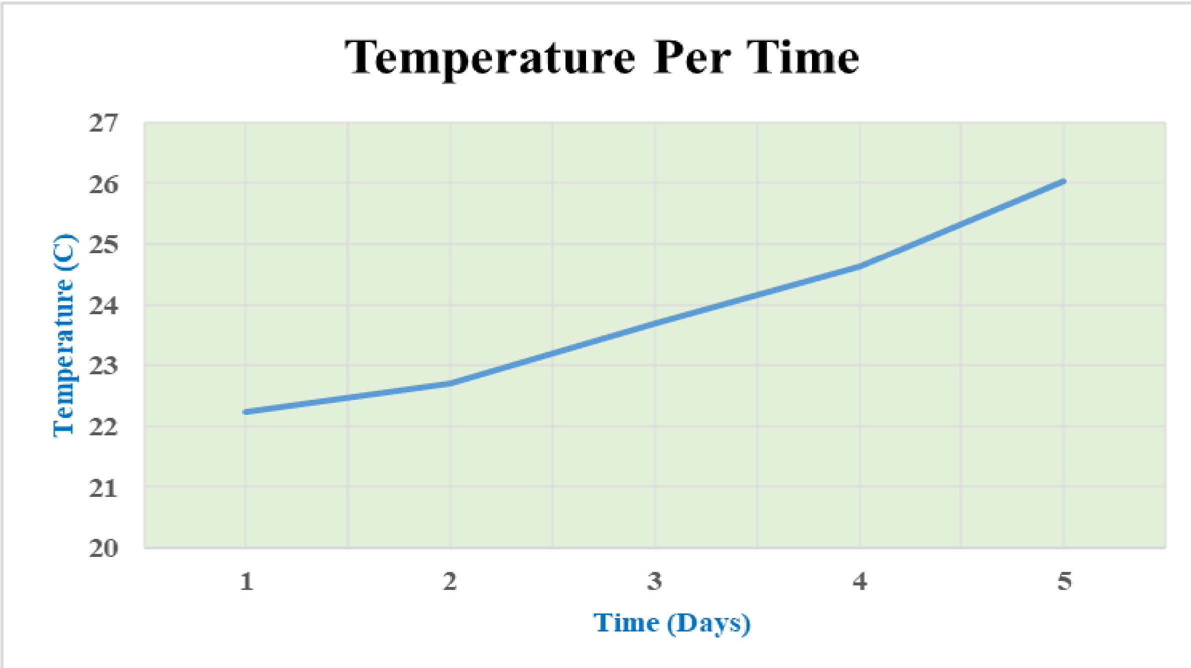


Figure 38

- A directly proportional relation between CO_2 and time; As time increases, CO_2 increases.

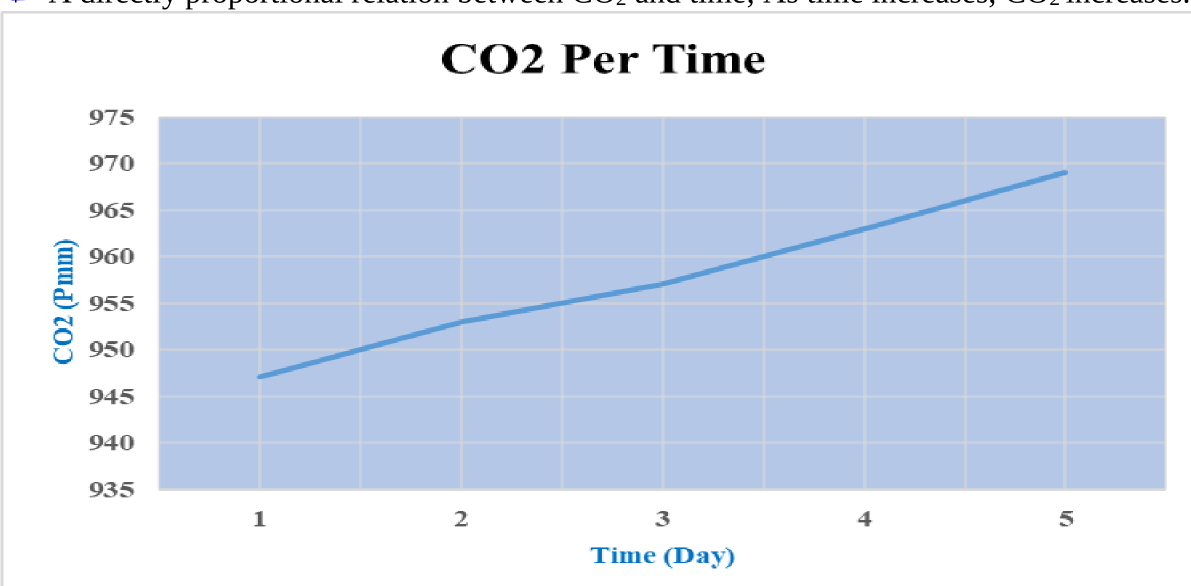


Figure 43

- A directly proportional relation between CO_2 and humidity; As CO_2 increases, humidity increases.

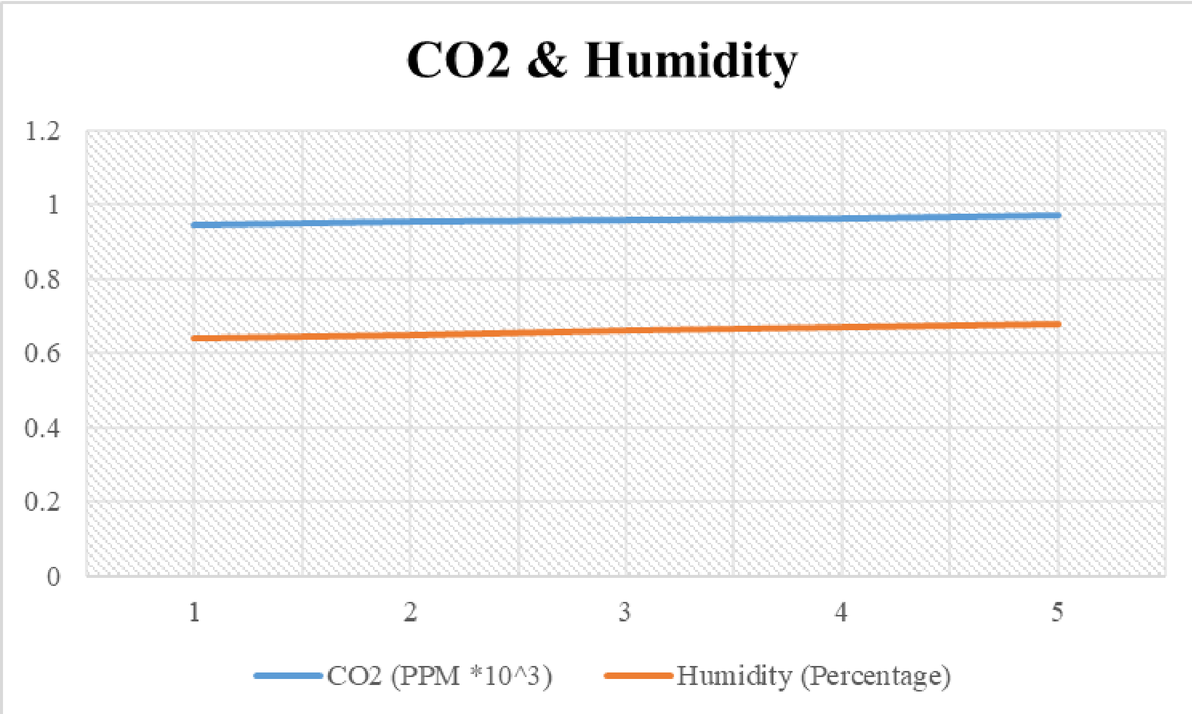


Figure 39

- A directly proportional relation between CO_2 and temperature; As CO_2 increases, temperature increases.

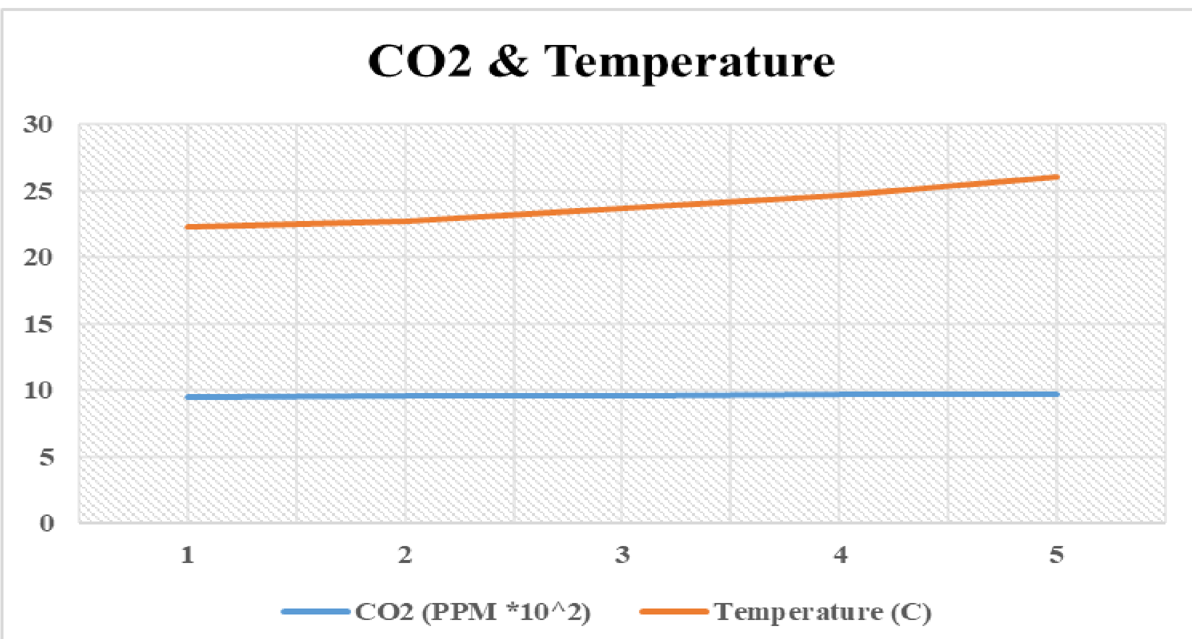
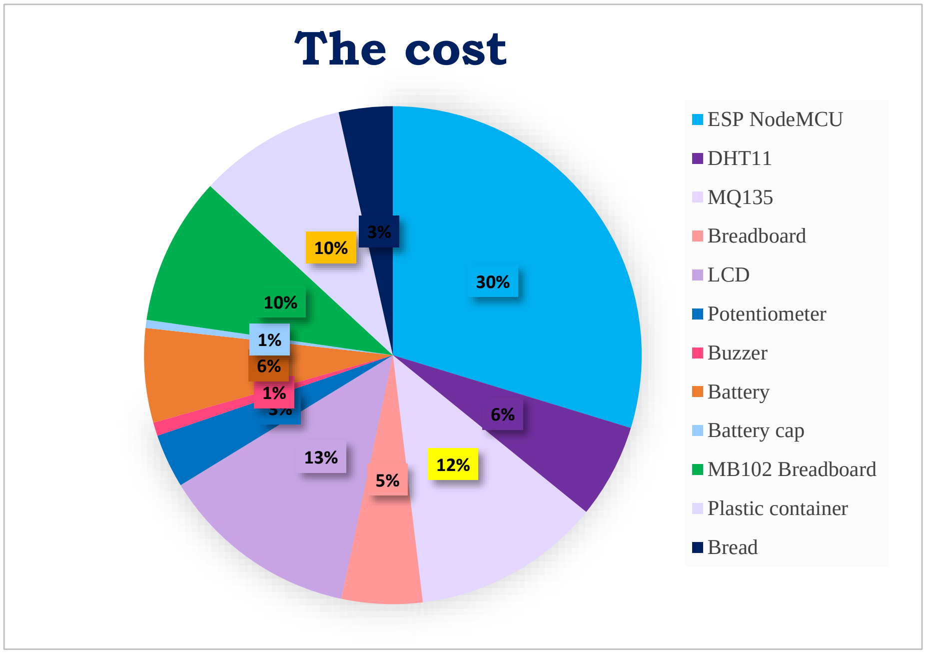


Figure 45

Cost Analysis:



Scientific concepts & Learning transfer:

The following scientific concepts were used to help us calculate and interpret our data:

- ***Biology:***

Studying anaerobic respiration and matter decomposition was our project idea's initial spark. Biology significantly helped us understand the gases released from such a phenomenon which was the primary inspiration for this project.

- ***Relative Humidity law:***

$$RH = \left(\frac{\rho_w}{\rho_s}\right) x\ 100\%$$

RH : $Relative\ Humidity$

ρ_w : $Density\ of\ water\ vapor$

ρ_s : $Density\ of\ water\ vapor\ at\ saturation$

- ***Physics:***

Studying communication and electronics, LO4 and LO5, helped us differentiate between analog and digital sensors. Subjectively speaking, it channeled our learning journey of how to use the DHT11 sensor, which is a digital sensor, and the MQ135, which is an analog sensor.

II. Conclusion

In our investigation, we concluded that rising CO_2 will contribute to increasing humidity and will affect the climate by raising temperatures, which will subsequently enhance global warming and have a detrimental impact on the whole planet. Our project is an IoT system that offers several advantages, including cost savings, improved productivity and efficiency, control and automation, expanded data collecting, and predictive analysis. All these IoT benefits enable us to obtain precise data and analyze the resulting information. As it showed high accuracy of CO_2 concentration, temperature, and humidity results with a low percentage of error. Additionally, compared to the results of other solutions, our prototype showed the much higher efficiency. Owing to the ability of our prototype to establish direct relationships between the outcomes of data gathered and their effects on climate. What's more, it was concluded that in order to fight climate change, it's a must for governments and countries to initialize recycling systems. It's crucial to categorize garbage in landfills (ex. Liquid garbage should be kept far away from dry, solid garbage), Place landfills in less humid, cold areas instead of hot, humid environments, and finally, avoid single-use products.

III. Recommendations

For applying the project on the large scale, some recommendations must be taken into consideration for stronger effectiveness and efficiency of the system. The following points summarize those recommendations:

- Using various organic matter to increase the amount of gases produced from the decomposition process, instead of depending on the decomposition of bread as a source of CO_2 only.
- Use the DHT22 sensor instead of DH11 as it has a better resolution and a wider temperature and humidity measurement range, and you can only request readings with 2 seconds intervals.
- Use ESP32 instead of ESP8266 NodMCU as ESP 32 has more than one analog pin that is needed for connecting more than one analog sensor with the ESP, while the ESP node MCU has only one analog pin that requires multiplexer to connect the sensors with the ESP.
- Using MG811 co2 sensor instead of MQ135, because it has a high sensitivity for CO_2 than MQ135.
- For better results and analysis, the system should be implemented in high-temperature conditions.

IV. Learning Outcomes

Table (8)

Subject	Learning outcome	connection
Chemistry	**Ch. 3.04** Identify and apply stoichiometric relationships to mass data to identify or infer the composition of pure substances and/or mixtures and relate mathematical processes to the analysis of the conservation laws and mechanisms of chemical reactions.	- Studying the LO "Concentration" was undoubtedly fruitful in helping us deal with gases like CO2 and methane CH4 by the MQ135 sensor. - As it helped us measure the concentration by using many rules but we use PPM (Part per million). PPM is commonly used as a dimensionless measure of small levels (concentrations) of pollutants in the air,
Chemistry	**Ch. 3.05** Use experimental data to derive the Ideal Gas Law.	- This unit is discussing gas laws which are considered Charles' Law, Boyle's Law, Combined Law, etc. All of these laws helped us in understanding more about the nature of gases. - This L.O has helped in defining how gases transfer and this comes through two attitudes: effusion which is the movement of gas from high concentration to low concentration through a hole and diffusion of gases from high concentration to low concentration. The effusion concept corresponds to the behavior of CO2 resulting from the industries that get out from chimneys.
Physics	**Ph.3.01** Analyze the motion of travelling transverse and longitudinal waves.	- This L.O. identifies the wave concept, which is the energy propagation between fixed particles. It has mainly two types: electromagnetic waves and mechanical waves. Also, it introduces how it propagates either along the line of propagation or perpendicular to it. So, it identifies the types of waves detected by sensors and how these sensors transmit wirelessly the data through electromagnetic waves.

Physics	**Ph. 3.04** Design a system of communication through applying previous knowledge (electronics, LASER, mechanical	- this L.O. introduces types of communication such as space, sky, and ground communication. Also, it identifies the main components of the system transmitter, channel, receiver, and 2 transducers: one at the transmitting side and the other at receiving side. The input transducer converts the message to an electrical signal, the transmitter converts the input signal to a transmitted signal, the channel is the electric medium that bridges the distance from source to destination, and the receiver converts the received signal in a form appropriate for the output transducer, output transducer converts the output electrical signal the desired message form. - Subjectively speaking, it channeled our learning journey of how to use the DHT11 sensor, which is a digital sensor, and the MQ135, which is an analog sensor.
Physics	**Ph.3.05** Describe how information can be transmitted via electromagnetic radiation	- This L.O. define types of data: digital data which are discrete in form of 0 and 1 and analog data which consists of a set of continuous data from 0 to 9. Also, it has defined two important processes: encoding which takes place at the transmitter where data is converted from analog to digital, and at the receiver decoding process takes place where data is converted from digital to analog.
Biology	**Bio. 1.10** Compare and contrast the processes of photosynthesis and cellular respiration	- Studying anaerobic respiration and matter decomposition was our project idea's initial spark. Biology significantly helped us understand the gases released from such a phenomenon which was the primary inspiration for this project.
Math	**Ma. 3.02** Analyze the behavior of functions by investigating critical points using first and second derivatives.	- Studying implicit and explicit differentiation, Maxima and Minima, and, generally, differentiation assisted us to calculate the rate of change or the slope of all the results which, indeed, came in handy with understanding the graphs, relations between variables, and, in general, the data better.

Computer science	**CS.2.09** Describe different basic programming codes and languages.	- We have learned the syntax of the JavaScript language which helped us in writing the code correctly and avoiding errors to program the sensors.
English	**En. 3.01**	- Learning about sentence structure helped us a lot in improving our academic writing to write the poster and portfolio with the right grammar and structure in an academic manner.
Earth science	**Es. 3.02** Analyze data sets that provide evidence for plate motions, including GPS	- This l.o introduce the Global positioning system (GPS) device that collects geographic coordinate data. This system correlates with the IoT system according to the mechanism of tracking data. Both include similar components: the control segment, channel segment, and user segment. The control segment consists of satellites and corresponds to it the sensors. Both are responsible for detecting measurements, the channel segment is where data obtained are processed, and finally, the user segment is where data is displayed.

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