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Assessing the concentration of air pollutants using sensors and Arduino

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Abstract
Due to the increased movement of vehicles, industries, and population growth, pollution occurs and plays a vital role in environmental issues. An experiment was conducted during 2020 to assess air pollutants' concentration using sensors and Arduino on five traffic signals. The experiment was laid out during the afternoon and evening at five traffic signals of Coimbatore district, Tamil Nadu State, using Arduino linked sensors viz., MQ-9, MQ-135 MQ-2. The analysis of pollutant gases from NO_2, CO, CO_2, and Air quality index (AQI), done by using breadboard and Arduino. Based on the results, NO_2 was 303-206 ppm, CO from 243-87 ppm and CO2 from 395-261 ppm and which relates to AQI of NO_2 is 119-139, proved unhealthy for sensitive groups, and CO of 1-2, is found to be safe and acceptable.

Key Word: *Arduino, industries, pollution, sensor, traffic*

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I. Introduction

The study area we have analyzed is Coimbatore. Where it is a district in the state of TamilNadu, India. Coimbatore consists of population about 2,860,000 and a growth rate about 2.62% at the year of 2021. It is also called as the Manchester of South India. Because it is famous for education and industrial activities. The density of the automobiles in a particular area results us the percentage of air pollutants. Urbanization and increase in population results in the forms of all pollution like air, noise & water.The analysis of air pollution in the cities of India is done by Naveen Kishore and Surinder (2017),where they received a rapid increases in air pollution due to the growth of population. This happens by increase of vehicles, fuel consumption, poor transport mechanism, land use patterns, industrialization and people concern towards the environment made this effect in Indian cities, also air pollution is becoming a major health problem that affects millions of people worldwide. Martha and Luis (2012)says that the World Health Organization estimates that every year, 2.4 million people die because of the effects of air pollution on health. The changes in diesel engine technology could results in fewer premature mortalities, and it's suggested by US Environmental protection Agency.

Many common air pollutants and greenhouse gases are present such as carbon dioxide (CO_2), methane (CH_4), and atmospheric aerosols (including black carbon, soot), have common source and interact in atmosphere that causes a variety of environmental impacts locally and globally in large scales. The air pollutants that have greatest effect on forest growth and health are tropospheric zone (O_3) and reactive nitrogen compounds, such as nitrogen oxide (NO_x), ammonia (NH_3), nitric acid vapor (HNO_3), and aerosol ammonium (NH_4^+) and nitrate (NO_3^-).

Iuliana and Barbu (2011) have analyzed the air pollutions from different gases, suspended particles, and different ionizing radiations. They classified into gases, which are oxidized and reduced. Particulate forms are PM10 and PM2.5 and heavy metals has toxic effects (Pb, Ni, Cd, As). These pollutants had made negative effect on plants, change in soil pH.Naveen Kishore and Surinder(2017) have also stated that the Sulphur dioxide, nitrogen dioxide, particulate matter are some of the pollutants which encourages the air pollution.

The sensors are used in many places to detect the contamination of air pollutant levels. There are highly equipment machines that detects a wide range of pollutant levels in the atmosphere. But it is not affordable by everyone. To handle the big machines, we need experienced and skilled labors to detect the contaminant levels in every area.

Sensors are nowadays the leading components that reduces the cost of machinery and simplifies the work easily in all fields of work. In the same way, it too have helped in analyzing air contamination of CO, NO, NO2 in the place of study. Also sensors are available in the market with less price compared to other

components which are costly. There are wide variety of sensors available to detect different types of activities in different study areas.

As we know that urbanization leads to air pollution and many people are affected by this problem. So to analyze the contaminants in the particular area, we have to calculate the air quality index, so that we can reduce the pollutant levels by planting trees and can also effectively reduce the emission of pollutants into the atmosphere.

II. Methodology

The study area is 11.0346° N, 77.0156° E, a place located in Coimbatore, Tamil Nadu.Naveen Kishore and Surinder Deswal (2017)have also reviewed many cities in India, where the contamination of air quality is polluted by NO2, SO2 and so on. Beth Gardiner (2019) says that air pollution is a mixture of chemical components, that includes fine particulate matter that is less than 2.5 micron diameter (PM 2.5), coarse particulate matter (PM2.5-10), ozone, sulfur dioxide (Sox), nitrogen oxide (NOx), & other chemicals. These chemicals are dangerous and are associated with variety of health effects and have been regulated over decades in the countries like Unites States, Europe, and elsewhere.

The figure 1 shows the test locations in the study area as L1, L2, L3, L4, and L5.

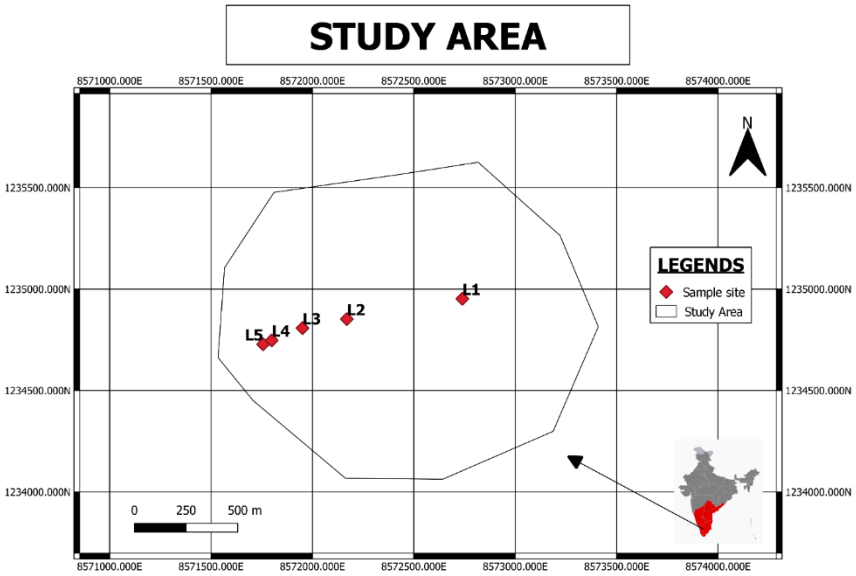

Fig 1. Study area

The air pollution includes both household air pollution (HAP) that originates from household (cooking, lighting, heating) and ambient air pollution (AAP) that is external building. This AAP can results by both man made source like electricity generation, vehicles, agricultural fires and natural processes like forest fire, wind-blown dust).

The major industry present is SIDCO, Coimbatore. Located at 10.9438° N, 76.9773° E. It is a private industry estate. The main cause of the Coimbatore air pollution is due to this industry where the AQI is 147 which is unhealthy for sensitive groups. (This data is collected in 7/12/2020 11:00). The recorded temperature is around 24℃maximum.

From the study areawe have analyzed the concentration of contaminated air in and around the campus by the air quality analyzing mechanism. It is made from Arduino Nano (Rev3.0) connected with MQ-9(CO2 Sensor), MQ-135(NO2 Sensor), MQ-2(CO Sensor) with the connecting pins D2 Pin on NodeMCU and D1 pin on NodeMCU in D1/TX & D0/RX. Coomon GND for NodeMCU and Nano is connected to the GND.

The components we used in the circuits are:

- Arduino Uno Board
- Male to female Jumper
- Bread Board
- Soldering materials
- MQ- 135(NO2 Sensor)
- MQ- 2(CO Sensor)
- MQ- 9(CO2 –Sensor)

SENSORS

The mechanism used to analyze the air pollutant levels is Arduino and its sensors. Where it is been connected with different sensors to detect the contamination of organic and inorganic gases present in the study area. The software used is Arduino, which validates the pollutant levels from different locations.

MQ-9 -This senor has high sensitivity to carbon Monoxide, Methane and LPG. Used to detect different gases contains CO, CO2 with low cost, and suitable for different applications. This sensor can be adjusted by using the potentiometer. It has good sensitivity to CO/ Combustible gas and has high sensitivity towards methane, propane & CO. Also it is cost effective and has long life.

MQ-135-The gas sensor is suitable for ammonia. Aromatic compounds, sulfur, benzene vapor and smoke including all other harmful gas detection. The Air quality sensor is for detecting a wide range of gases, including NH3, NOx, alcohol, benzene, smoke and CO2. It has high sensitivity towards sulfide, smoke and other harmful gases, cost effective and has long life. Also it has simple drive circuit.

MQ-2- The senor has high sensitivity towards LPG, Propane & Hydrogen also can be used to detect methane with low cost and suitable for several applications. Has good sensitivity towards the combustible gas in wide range and has high sensitivity to LPG, Propane and hydrogen. Also it has simple drive circuit, where it is cost effective and have long life.

The circuit diagram is shown below

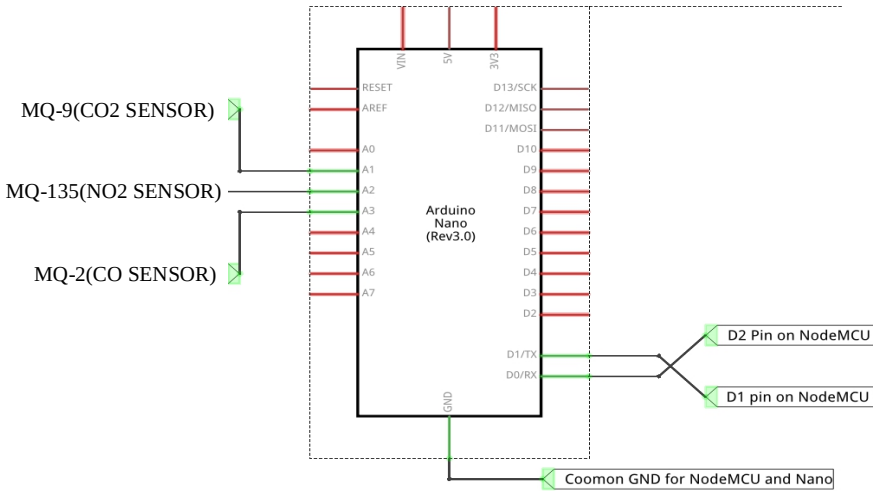

Fig 2. Schematic circuit diagram

The Arduino is said to be connected with the breadboard with the help of wires and sensors in it. The sensors like MQ-9, MQ-135, and MQ-2 is connected to the breadboard and also in the Arduino in the slot of analog of A2, A3, and A4. The connections are shown in the figures below.

In Arduino software, coding's are been incorporated to get the output values which the sensors observe. Choose the location, where the observation of the pollutants must be assessed. Turn on the Arduino and wait for some time, the sensors observe the pollutants in the particular location and shows the output in the software. Note the values and proceed with next location simultaneously.

The values recorded in different locations are found as ppm (parts per million), where it's been discussed below and converted into AQI to find the quality of air as safe or unhealthy.

III. RESULTS & DISCUSSION

The analysis were conducted during Afternoon and in Evening session and the detailed test results are shown below:

Table 1: Location wise pollutants for two session

Location	Afternoon			Evening		
	NO_2 (ppb)	$CO_{(ppb)}$	CO_2 (ppb)	NO_2 (ppb)	$CO_{(ppb)}$	CO_2 (ppb)
L1	257	178	357	278	243	395
L2	236	158	359	250	230	358
L3	230	137	326	210	150	261
L4	212	94	331	303	287	299

L5	226	87	335	206	141	318

The values obtained are NO_2, CO, CO_2at 5 different traffic signal hotspots at equal interval of time. The temperature found in afternoon is of 33°C and humidity of 28% and temperature found in evening is of 30°C and humidity as 42%.

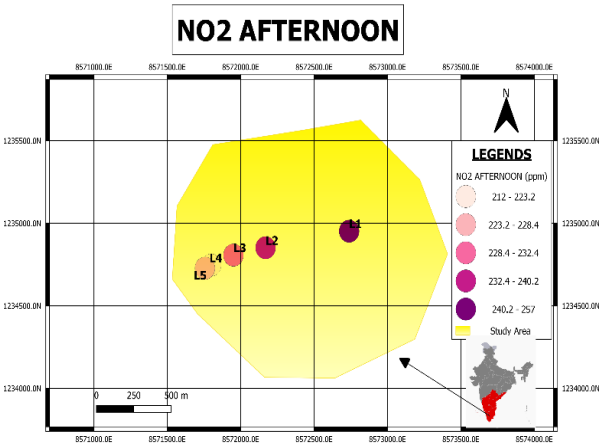

Fig 3. Concentration of NO2 at afternoon

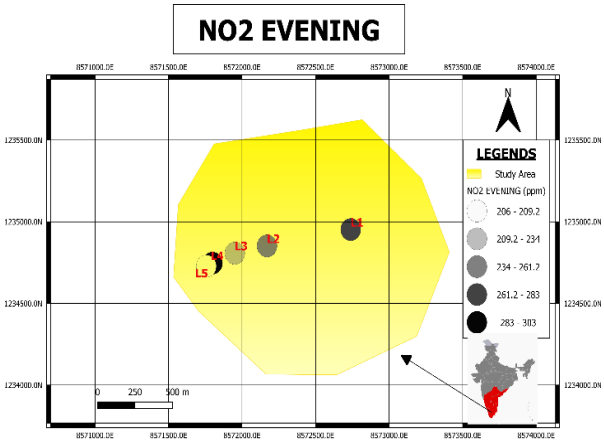

Fig 4. Concentration of NO2 at evening

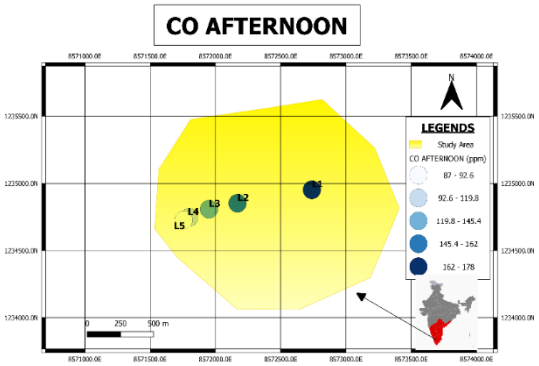

Fig 5. Concentration of CO at afternoon

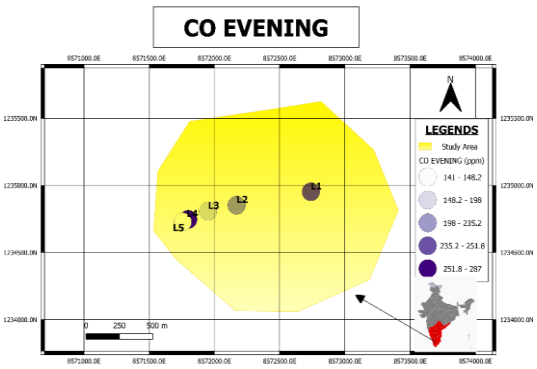

Fig 6. Concentration of CO at evening

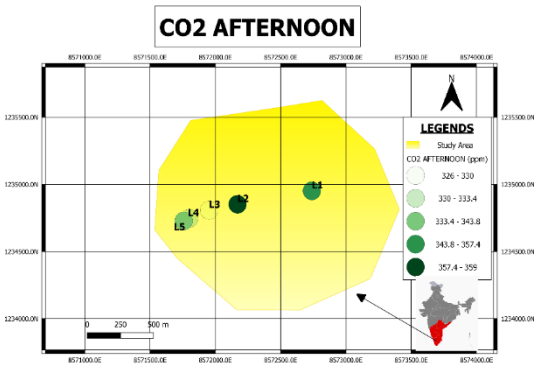

Fig 7. Concentration of CO2 at afternoon

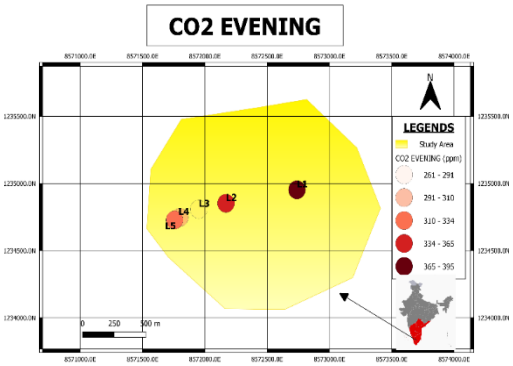

Fig 8. Concentration of CO2 at evening

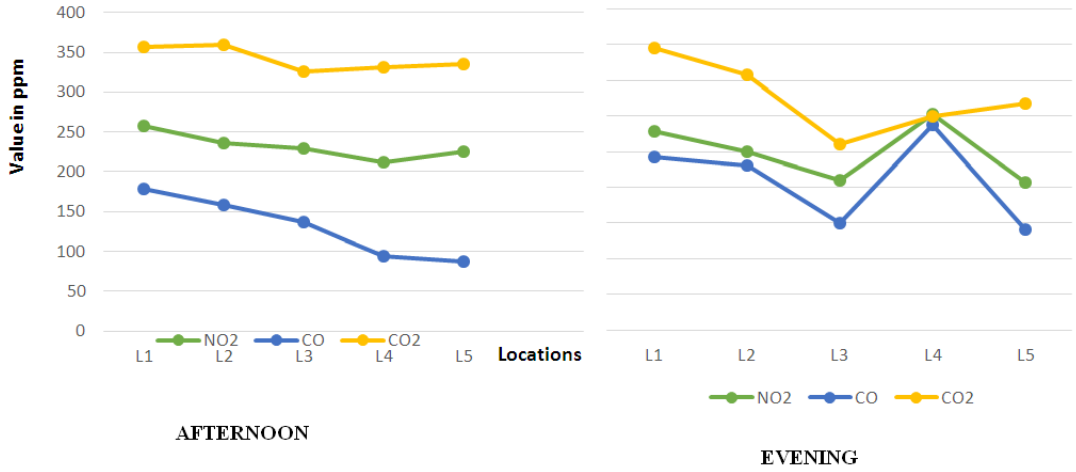

Table 2. AQI and Concentration of pollutants

Pollutant	Concentration	AQI
NO2	191-303 ppm	118-139 (Unhealthy for sensitive groups)
CO	87-287 ppm	1-2 (Good)

From the above table, we can say that NO2 has a concentration of 191-303 ppm at the site and has the Air Quality Index (AQI) of 118 – 139. This says that the AQI level for NO2 is higher compared to CO. From the AQI chart we can say that, this percentage is unhealthy to human bodies and affects the air quality in the environment. George Thurston (2015)have reviewed and confirmed the air pollution of Ozone, Nitrogen Dioxide, and Sulphur dioxide, which made him to study the effects on the health issues in different people.

Doba et al (2020)have made a study on seasonal effect of atmospheric matter. In turkey, the highest solar radiation levels has been recorded in southern Anatolian region. The provinces are subjected to particulate matter (PM) which comes from Sahara desert, Syrian and Arabian Desert by atmospheric transportation. The daily limit of PM10 and PM2.5 is said to exceed in the region of Sanliurfa, which was set by WHO.The exploration of NO2 data has confirmed the study of Susanna et al (2019) where it caused mental health problems in London. They conducted an analysis of 284 London-based children's from the environmental risk (E-Risk), where they are exposed to PM2.5 and NO2 concentration at different levels and the children's were aged 12.

The HighestCO_2 content is recorded in the afternoon atlocation L2. The results corroborated with the findings of Kamath and Lokeshappa (2014**)**on the pollutant levels in different cities in India. The studied proved in Bangalore which had air pollutant concentration at the locations of residential, Industrial and sensitive areas. The analyzed pollutants are SO2, NOx ad RSPM, recodred in six places in Bangalore.The NO2 is measured in the area of Naroda Lake with maximum of 25 µg/m and minimum of 17µg/m in the Gandhinagar shopping center, sector-8 and also for the reduction of CO2 Joris koornneef et al., (2011) have said carbon capture and storage (CCS) is a technology concept which reduces the emission of CO2 that results from various industries

Xiaojing et al (2014)have reviewedand analyzed the carbon dioxide (CO2), which is colorless and odorless gas. The CO2 in open air is about 350-400 ppm in concentration of buildings is said to be higher even up to the levels of 4000-4500 ppm. Thus levels of pure CO2 below 5000 ppm have some negative effects on health issues.

There is an increase in carbon monoxide levels in the atmosphere in the evening, where it has increased in all the location of the site. As said by Beth Gardiner (2019) due to the industrialization and the carbon content emitted from the households and institutions, results in increase of CO content in evening session. The CO content analyzed in the study area is 87-287 ppb, where it looks like a good one. The AQI ranges from 1-2 (Good), this makes the health problems less compared to other increased parameters. The cardiac arrest of CO poisoning which is acute exposure to very high concentration of CO (1000-10000 ppm). This makeshealth issues comparatively higher than the results obtainedfrom my study. This shows that the CO content which is liberated in industry, households, and indoor grounds are said to increasing in many places, but comparatively my study results as good AQI level. We can also further reduce the emission of CO content by planting absorptiontrees, which reduces the emission of CO in the atmosphere.

Deval et al. (2019) has analyzed the effects of air pollutions on human health and environment. It causes irritation of eyes, throat and noses, wheezing coughing and breathing difficulties and has a great risk of heart attack. The most risk people are children, older adults, who has heart or lung diseases such as asthma.

The effects and causes of the increase in NO2, gives asthma, pulmonary ailments, irritation of eyes, nose and throat, severe effects on animals plants and whole environment. These will affect the young children and aged people also.

IV. CONCLUSION

By the above results we can conclude that the study area we have analyzed is said to be unhealthy and has mild air pollutant content with increase of CO_2 content in different locations in the area. This gives an alarm that still many places like these are said to be contaminated by toxic gases and that leads to various health and environmental issues. This pollutants can be reduced by planting Pine, Oake, Douglas, neem, saga and many more for the absorbing harmful pollutant gases present in the atmosphere. By this we can reduce the contamination of toxic heavy metal gases into air, which enhances good livelihood for humans and to animals

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