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Air Pollution Monitoring System using IoT

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Abstract--- Air pollution has a very adverse impact on human beings and our ecosystem. With the rampant industrialization and exponential growth in automobile industry, the air gets highly contaminated by harmful toxins & gases released from their emissions which results into many hazardous diseases like asthma, bronchitis, mental illness, lung cancer etc. Hence the air pollution should be carefully monitored and efficiently controlled. Using internet of things (IoT) we can simultaneously gather pollutants level in highly explicit areas and transmit the data to centralized controlling and monitoring unit where suitable steps can be taken to warn people so as to reduce the level of pollutants in the air significantly.

Keywords—Air pollution, Air pollutants, Air quality index, Internet of things, Sensors.

I. INTRODUCTION

Air quality index (AQI) plays a pivotal role in sustenance and functioning of our habitat and hence the whole ecosystem. With rapid economic and industrial development followed by large influx of automobile industry, emitting unwieldy amount of toxic gasses and particulate matter (PM) in the air results in polluting the atmosphere causing air pollution. Air pollution occurs because of impurities (particles) and gases that mix with the air and can reach harmful concentrations both outside and indoors. Breathing dirty air makes human beings vulnerable to various toxins in the air causing great harm. It may also affect ecosystem and may even cause destruction to it. These toxins may reach our lungs, heart, bloodstream and brain resulting in respiratory problems like asthma attacks, chronic pulmonary diseases, lung cancer, pneumonia, coronary artery disease, chronic bronchitis, and can even cause rise in mental illness. Those people who work in factory or in constructional sites are very vulnerable of falling ill because of emissions and dust particles. As Developing countries are most prone to extreme air pollution and India being one of the rapidly developing economy is also one of the most polluted country [1]. According to the world health organization (WHO), nine out of ten people breathe air with high levels of pollutants [2].

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Among all the health risks air pollution is currently 3rd major cause of death in India. In south Asian child's the average life span has being shortened by two and a half years due to air pollution [3].

The statistics is shown in fig.1. According to the State of Global Air 2019, nearly 5 million deaths occurred from various diseases like diabetes, lung cancer, stroke, heart attack and chronic lung disease in 2017 due to chronic exposure to air pollution. Out of these 3 million deaths are directly attributed to PM2.5, half of which were in India and China. The analysis found that China and India together were responsible for over half of the total global attributable deaths [4]. Reports also claim that the air pollution was responsible for 7 million premature deaths in 2016, of these almost 600,000 were children under 5years [2].

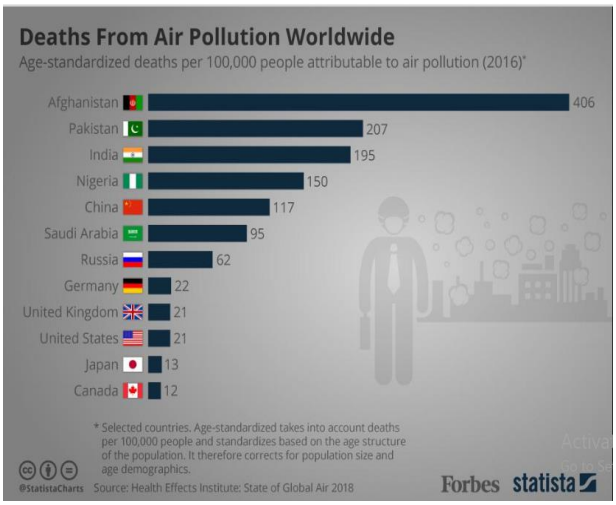

Figure (1) Statistics of death due to air pollution [4]

According to the Environmental Protection Agency (EPA), the air pollutants that are common are Lead, Nitrogen Dioxide (NO_2), Sulphur Dioxide (SO_2), Volatile Organic Compounds (VOC), Suspended Particulate matter (SPM), Carbon Monoxide (CO) and Ozone (O3)

•Carbon monoxide: The main source is transportation and it contributes 72% of total air pollution [5]

•Lead: Natural ore, piston – engine aircraft operating on leaded aviation fuel and metals processing are some of major sources of lead in atmosphere. The highest concentration of lead is usually found near lead smelters.

•Nitrogen dioxide: It is present in air due to burning of fuel

•Ozone: It reaches in our atmosphere when emissions from power plants, vehicles, chemical plants and other sources react with heat and sunlight. Its concentration is extremely high during period of April 1 to September 30.

•Sulphur Dioxide: It is found near large industrial complexes. Major contributors are power plants, refineries and industrial boilers. It is formed due to combustion of high Sulphur fuel as well as volcanoes.

•Volatile Organic Compounds (VOCs): Sources include paints, cleansers, disinfectants, aerosol sprays, air fresheners, moth repellents, stored fuels, dry cleaned clothing, pesticide, building materials and furnishings

•Suspended particulate matter (SPM): It is formed when solid particles gets mixed with liquid droplets in the air. Most of the particles in air are due to the complex reaction of chemicals such as SO_2 and NO_2 that are emitted by power plants, automobiles and industries

PM2.5 and PM10 are one of the major identifying components of air quality and pose higher human well being because of their capacity to break the natural defense system of the body and may cross into the blood stream. The IQ Air Visual 2018 world air quality report showed that Delhi remains the most polluted capital city across the world with Gurugram being the worst affected as shown in figure 2.

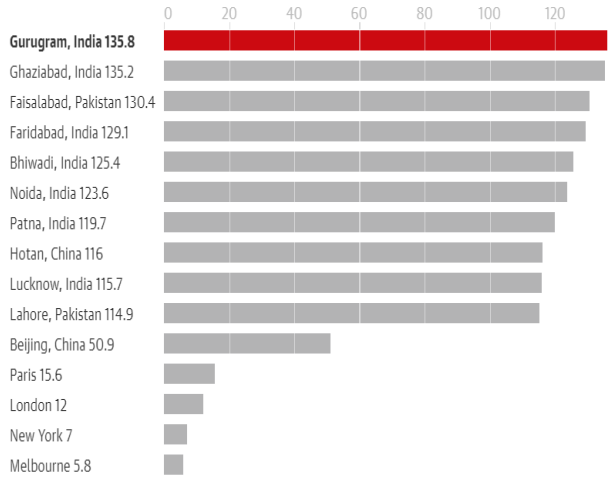

Figure (2) Annual mean concentration of PM2.5 (micrograms per cubic meter) [6]

Unfortunately air pollution is a man-made. In an effort to control the air pollution, it needs to be monitored. The objective of monitoring air quality is to gather the data and to make the information available to the public, policy makers, scientists, and planners to allow them to take necessary steps to manage and improve the environment. To communicate the levels of pollutants in real time to the public, Air Quality Index (AQI) is used [7]. Continuous monitoring stations captures data without human interference and it is displayed in figure (3) and (4) based on running average values.

AQI Category, Pollutants and Health Breakpoints

AQI Category (Range)	PM_{10} 24-hr	$PM_{2.5}$ 24-hr	NO_2 24-hr	O_3 8-hr	CO 8-hr (mg/m^3)	SO_2 24-hr	NH_3 24-hr	Pb 24-hr
Good (0-50)	0-50	0-30	0-40	0-50	0-1.0	0-40	0-200	0-0.5
Satisfactory (51-100)	51-100	31-60	41-80	51-100	1.1-2.0	41-80	201-400	0.5 – 1.0
Moderately polluted (101-200)	101-250	61-90	81-180	101-168	2.1- 10	81-380	401-800	1.1-2.0
Poor (201-300)	251-350	91-120	181-280	169-208	10-17	381-800	801-1200	2.1-3.0
Very poor (301-400)	351-430	121-250	281-400	209-748*	17-34	801-1600	1200-1800	3.1-3.5
Severe (401-500)	430 +	250+	400+	748+*	34+	1600+	1800+	3.5+

Figure (3) Air Quality Index [7]

AQI	Remark	Color Code	Possible Health Impacts
0-50	Good		Minimal impact
51-100	Satisfactory		Minor breathing discomfort to sensitive people
101-200	Moderate		Breathing discomfort to the people with lungs, asthma and heart diseases
201-300	Poor		Breathing discomfort to most people on prolonged exposure
301-400	Very Poor		Respiratory illness on prolonged exposure
401-500	Severe		Affects healthy people and seriously impacts those with existing diseases

Figure (4) AQI Health Breakpoints [7]

Real time pollution statistics can be collected and monitored by using smart sensors. In addition to that IoT technology can be integrated remotely to detect pollution without any human intervention. IoT is the network of physical objects that contain embedded technology to communicate and sense or interact with their internal states or the external environment. Each IoT device may have unique ID and unique identifier and convey information. IoT enable devices to communicate with each other, to access the information on the internet, to collect & store data and then sharing with the users, thus creating smart, ubiquitous and perpetually connected network [6]. Data can be interpreted via any electronic device, where every physical will have sensors, displays and other embedded devices installed on it and connected through a network.

Sensors are those hardware units that are used to monitor the environmental and physical conditions. A sensor senses changes in the ambient conditions and processes this information in a certain manner. The analog signal sent by the sensors is converted into digital signal by an analog to digital device and it is further sent to controller for any processing.

II. LITERATURE SURVEY

In paper 1 [7], the authors find the pollutants using IoT. Sensors used were UVI-01 for ultraviolet radiation, BMPO85 for pressure and temperature, LDR light dependent resistor , TGS 2600 for general air quality, MICS-2710 for NO_2, MICS-5525 for CO. Proposed system monitors all the results and the data is sent to cloud. Action will be taken according to the generated report

In paper 2 [5], the authors main focus is on measuring air pollution caused by vehicles on the city roads using IoT. The measured air quality status is reported to the concerned agencies, vehicle owner and traffic department. The proposed system guaranties low cost sensors that give good results in controlling the air pollution [6]

In paper 3 [9], for the evaluation system, the authors use sensors namely MQ135, MQ4, MQ9 to transmit data to the cloud through IoT. To check the variation of pollutants, the proposed system can obtain the levels of vehicle discharge and can take tests in real time or at some other time interval.

In paper 4[10], the authors use sensor with Wi-Fi modules. The proposed system measures concentration of gases and the collected data was provided to base station that is raspberry pi. A mean stack was prepared to show data on website. The mentioned method lets us to reduce cost infrastructure for data collection and dissemination to stakeholders. Sensors MQ7 for Carbon Monoxide (CO), and MQ135 for NH_3, CO_2 were used.

In paper 5[11], the authors use low cost sensors that assures accuracy, and makes monitoring area more systematic. The field data gathered by front-end sensor network in accordance with neural network performs the real time analysis of the collected data and provides real and effective solution

In paper 6[12], the authors use sensors for detection of pollutants in air. The data collected by IoT system is sent to the concerned authority. There the analysis of given data is done and a it is compared against a threshold value. If the measured value is greater than threshold value it will trigger an alarm, hence it will take suitable actions to warn surroundings.

In paper 7 [1], the authors choose a specific area (Agra) and make extensive study about NAAQS standards, USEPA standards, EUPAQ standards, WHO standards on fine PM(particulate matter) and various other aspects like causes, effects, control of air pollution through consciousness.

In paper 8[13], the authors develop the smart sensors that consist of noise level(dB), particular matter(PM10) sensor, carbon dioxide and ozone. The results illustrates air quality index via Narrowband Internet of Things (NB-IoT) which inform people about real time air quality.

In paper 9[14], the authors main focus is on automobile pollution. Their work gives us a real time solution through a sensor deduced hardware module fixed at certain locations that monitors pollution and take measures to reduce the traffic in densely polluted areas. The algorithm predicts the air quality and the proposed system transmits the calculated information for traffic control purpose and through mobile application.

In paper 10[15], the authors use IoT based air pollution monitoring and prediction system for analysis and forecasting of air quality by using air sensors to communicate data to microcontroller. For prediction, Long Short Term Memory (LSTM) is implemented.

III. SITE DESCRIPTION, SAMPLING, ANALYSIS AND STUDY AREA

In the study of air pollution at Greater Noida which is mainly due to emissions from the vehicles, industries & population growth. The data was collected from Greater Noida-UP pollution control board [16]. The collection and interpretation of data is done from Ist June 2018 to Ist March 2019. The monthly variations in the air pollutant parameters (PM10, PM2.5, SO_2, CO, Ozone, NO_2) are presented in fig 5,6,7,8,9,10. [16]

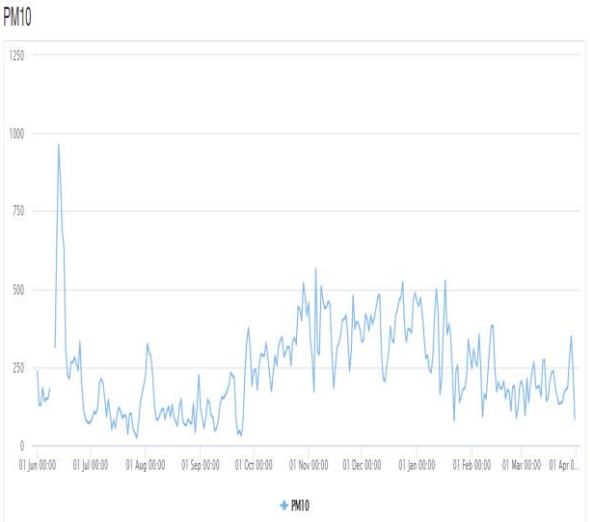

Figure (5) Monthly variation of PM10 [16]

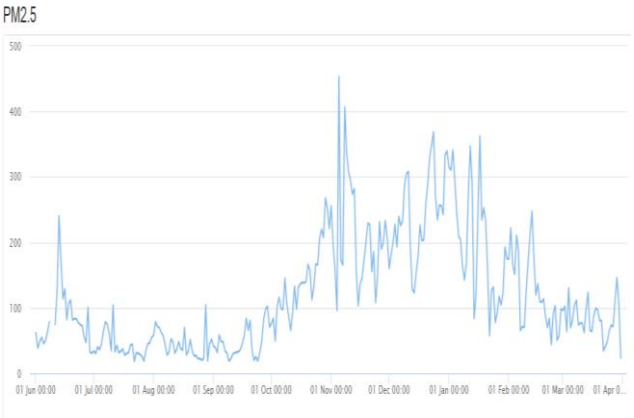

Figure (6) Monthly variation of PM2.5 [16]

Figure (7) Monthly variation of So_2 [16]

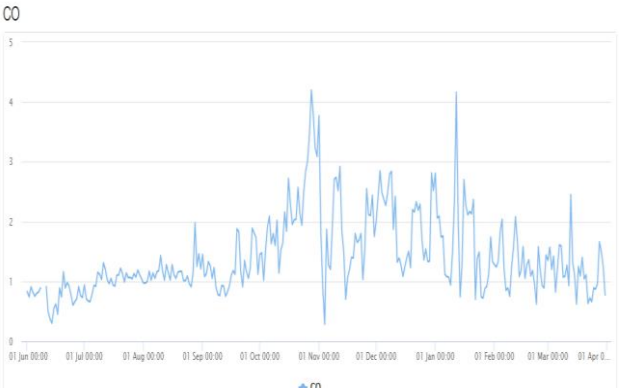

Figure (8) Monthly variation of carbon monoxide [16]

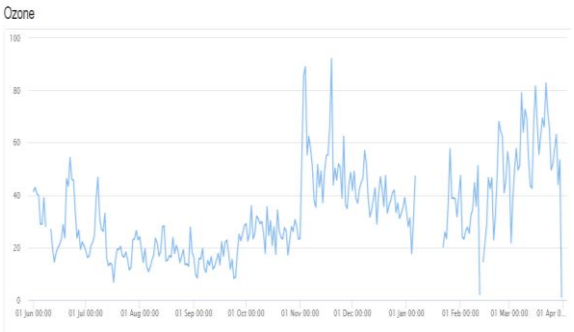

Figure (9) Monthly variation of Ozone [16]

Figure (10) Monthly variation of No_2 [16]

IV. PROPOSED WORK

The below figure (11) gives us conceptual view of our system where data can be extracted from many remote locations using sensor

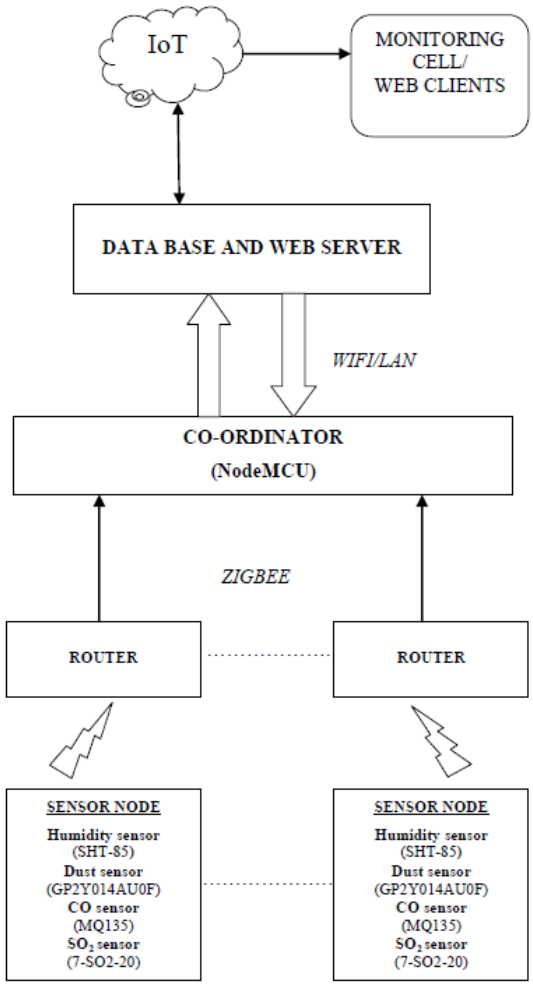

Figure (11) Block diagram of the proposed system

The data obtained includes temperature and humidity of the area, particulate matter (PM), concentration of harmful and toxic gases like CO and SO_2. The data collected from the field will be in analog domain. The data will be routed and digitalized further will be stored digitally on server from where it can be easily be accessible by the controlling and monitoring unit using IoT. IoT enables us to gather and transmit the data collected in more user friendly format to websites or phone applications which will not only make the people more aware about the pollution level in their area but they will be able to understand when and at what time of the day to take precautions to protect themselves from various health hazards.

V. RESULT ANALYSIS

The Air Quality Index (AQI) analysis of Greater Noida shows that PM10 and PM2.5 are in objectionable level during the months of June-July and November-February, having high concentration of 961.71 and 452.97 respectively. The levels of SO_2 (40-50) and Ozone (80-100) are satisfactory. The CO levels (4-5) in October-November and January-February are moderate. NO_2 levels (150-200) are moderate during December-February. During rest of the year the concentration of these gases are in satisfactory level in this area.

VI. CONCLUSION AND FUTURE WORK

It can be concluded that we need a highly competent and robust system capable of providing with accurate readings of real time data (pollutant levels), so we can take immediate measures to control the pollution levels. This can be accomplished by an IoT based system as given earlier figure (11).

Further to minimize the levels of PM10 and PM2.5, a Sensor based stagnant water pump can be used for spraying the water that can communicate through IoT system. The sensors will detect the pollution levels and if the pollution level is increased beyond the predefined threshold value (according to AQI standards), then with the help of sensors and applying internet of things (IoT) techniques i.e. the pollutant data will be first collected from area under consideration and the data will be transmitted to the cloud using a coordinator (node mcu) where the further steps to control will be mentioned and hence using IoT gateway it will communicate the actions to the water pump and finally, the water can be sprayed automatically to the surroundings minimizing the levels. The main advantage is that it can save money as well as time.

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