26. Monitoring air pollution Based on Internet of Things (IoT) and Interfacing of Microcontroller with VGA display

Shahir Uddin, Electronics & Communication Engg., Birla Institute of Technology, Patna Campus Patna, India shahir@bitmesra.ac.in
Kamal Kant, Electronics & Communication Engg., Birla Institute of Technology, Patna Campus Patna, India kamalkant2291@gmail.com
Vishal Kumar, Electronics & Communication Engg., Birla Institute of Technology, Patna Campus Patna, India vishal2400034@gmail.com
Dharmendra K. Singh, Electronics & Communication Engg., BIT Sindri, Dhanbad, India dksingh@nitp.ac.in
M. A. Hassan, Mechanical Engg. Department, NIT Jamshedpur, Jamshedpur, India hassan@bitmesra.ac.in

ABSTRACT

With the rapid advancement's of technology to fulfill the necessities of humans and overconsumptions of resources to drench their thirst of led to worsening the environmental condition. Various factors like industrialization, urbanization, deforestation etc. contributed to this adverse situation. The other most important factor behind this scenario is negligence or improper real time monitoring. Real time monitoring of the Air Pollutants with IoT based technology will provide ambient data with the cloud service will help in controlling this degrading Air Quality. This paper concern about providing an mobile and portable Air Pollution monitoring device to monitor the concentration of pollutant which would be powered with 3.3V only. The data monitored can be sent to the cloud which can be remotely accessed using android applications. This will facilitate the users to fetch the data of remote areas in the real time and also be displayed over the VGA display interfaced with microcontroller.

Index Terms— *Video Graphics Array; Particulate Matter2.5; Air Quality Monitoring; IoT.*

INTRODUCTION

In the present Era of development, environment is left with increased concentration of air pollutants. Air pollution is the main concern for all the developing as well as the developed countries. As per the studies after poverty Air pollution is the major problem faced by the world today. Humans are at the verge of treating development and advancements compromising with the life-threatening issues. The rapid increase in the concentration of various harmful gases in our atmosphere causes have adverse effects on humans and ecological community[1]. Air pollution may be linked with lung's impairments[2],[3], cardiovascular diseases[4], lung cancer, community acquired pneumonia.This paper deals with the monitoring of harmful pollutants and simultaneously displaying the sensors data over VGA display. Along with monitoring of gas pollutants, making people aware of the adverse effects of those is required by keeping regular track of these gases. Suspended particulate matter (SPM), carbon monoxide (CO), oxides of nitrogen (NO), oxides of sulfur (SO), lead aerosol, volatile organic compounds (VOC) are the main constituents of air pollutants [5][6].This will led them to take some precautionary measures and steps to fight or overcome these silent Killer pollutants [7].These not only making our live worse but also decreasing their average life expectancy by 1.8 years [8]. If people along with theinitiative taken by the government contribute to fight against this problem, the can be controlled and reduced up to some extent for the better future. The rise of population in the upcoming century, mainly in the developing countries there is a lack of capital for the major concern like air pollution control and it signifies that gradually the conditions will worsen in many more cities that will reach megacity status.[9]. As far as sustainability is concerned the ozone depletion, poverty and air pollution is the major problem faced by the world.[10] According to the data estimated by WHO 12.6 million of global deaths is due to environmental factors[11].

This paper presents real time wireless monitoring of the harmful pollutants and simultaneously displaying sensors data over VGA displays[12].The VGA(video graphic Array) standard display is able to both read and write hardware registers and offers increased 640×480 color resolution [13].So, we in way of providing a simplest and modular Air Quality Monitoring device which will send the sensor data over cloud and then it will be fetched using Mobile Applications.[14] It can be also displayed over VGA display panels mounted for forecasting the concentration of gases of different areas replacing those LED display panels. These displays will not give out the sensors data and also used for displaying precautionary measures in case of alarming increase of concentration of pollutants. These displays are less power intensive than the older one and provide good interface and performance. Along with sensing, making this device compatible to IoT (internet of things) will provide an easy access to the sensors data and make data acquisition lot easier [15]. This will provide a kind of real-time air pollution monitoring and forecasting system by sending the data over cloud platform and then fetching the data on mobile applications.

PROPOSED MODEL

To meet the requirements of the advancement in the field of electronics the need of decrease the device size in order to increase its compatibility and mobility is important. By using single chip microcontroller this model took a form of standalone device. Various Gas sensor, temperature and humidity sensor along with Wi-Fi enabled chip ESP8266 makes it easier for real time monitoring of gasconcentration of the atmosphere. The data fetched by the sensor also uploaded over cloud storage in real time so that it can also be remotely accessed.

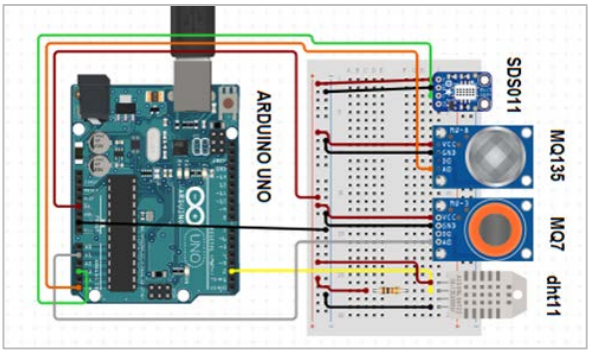

Figure 26-1 Circuit diagram of the model

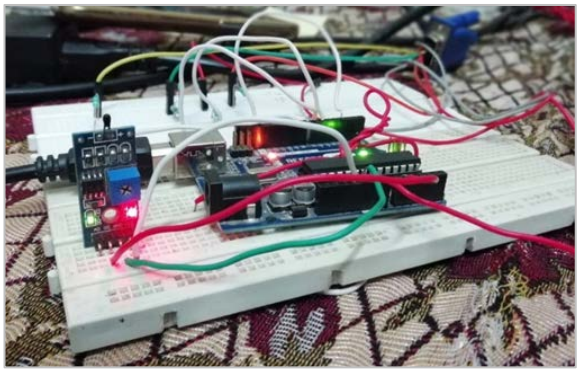

Figure 26-2 Hardware model

These circuit diagrams in fig.26-1 represent real time air pollution monitoring device. The data received from the device will be sent to cloud, stored and will also be displayed over VGA displays. The use of several semiconductor sensors has advantage of low cost, small size and high precision. This will provide a wireless real time air pollution monitoring system, designed using a microcontroller to measures the levels of various air pollutant's concentration.[16]Converting sensor acquired data from analog to digital value of air pollutant i.e. Co,NO2&SO2 etc. these are sent to the cloud using the Wi-Fi modem. Although the display board used so far for displaying air pollution monitoring is power intensive and bulky, so we use here is the VGA based display monitors. the microcontroller is been interfaced by the VGA monitor display for displaying the data of air pollution monitoring. the circuit connection of microcontroller is done with the help of resistance matrix and VGA cable. the resistance matrix connects the incoming output signal of microcontroller to the VGA connector cable to display the sensor data output in a required format. This will provide regular update of Air Quality Index(AQI) in the vicinity of the device. Based upon this AQI the quality it has been categorized in six levels namely Good, Moderate,Unhealthy, Very Unhealthy, Hazardous.[17]

The sensor data can also be displayed over VGA monitor such that it can provide these information over large displays. This can display the variation of sensor data due to changes in the concentration of gas in the surrounding. the signal generation of the VGA display can be done by obtaining the Arduino pin voltage to certain specific value in order to get different colours. This can be done by using resistances of different

value to drop the pin voltage of Ofarduino to certain value. in order to get the balck color the voltage at the vga pin should be 5V and similarity based upon these resistance values colour signal will get generated.

The sensor output is fetched through the microcontroller and simultaneously displayed over the VGA display. This interfacing approach overcomes the scalability of size of displays used. The Video Graphic Array display provides color interface with the help of resistors of different values in order to regulate the voltage which corresponds to different color combinations.

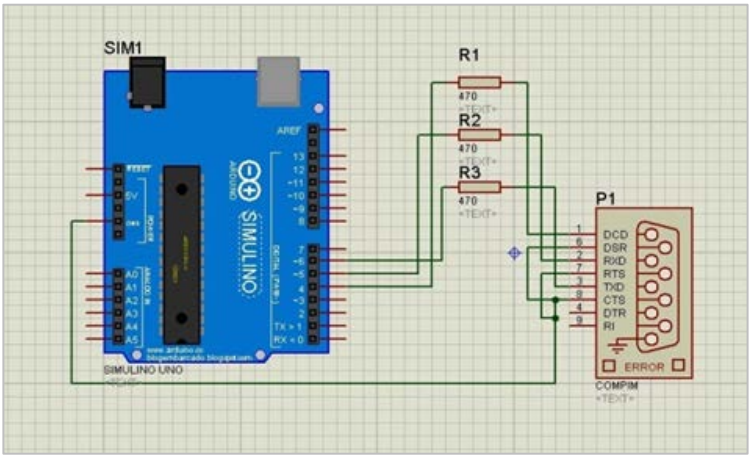

Figure 26-3 circuit Diagram of Arduino due to VGA port

This provides an easy access to get the desired data of whatever needed within short span of time.So, we are also working on the same. We are likely to provide these sensor data on Android Apps fetching the sensor data from cloud platform. The steps for initializing the uploading the sensors data over the cloud platform are to connect the microcontroller to Wi-Fi module with the specified pins mentioned in the data sheet. Then with the help of boot loader code has been uploaded to the board using specified burner software.

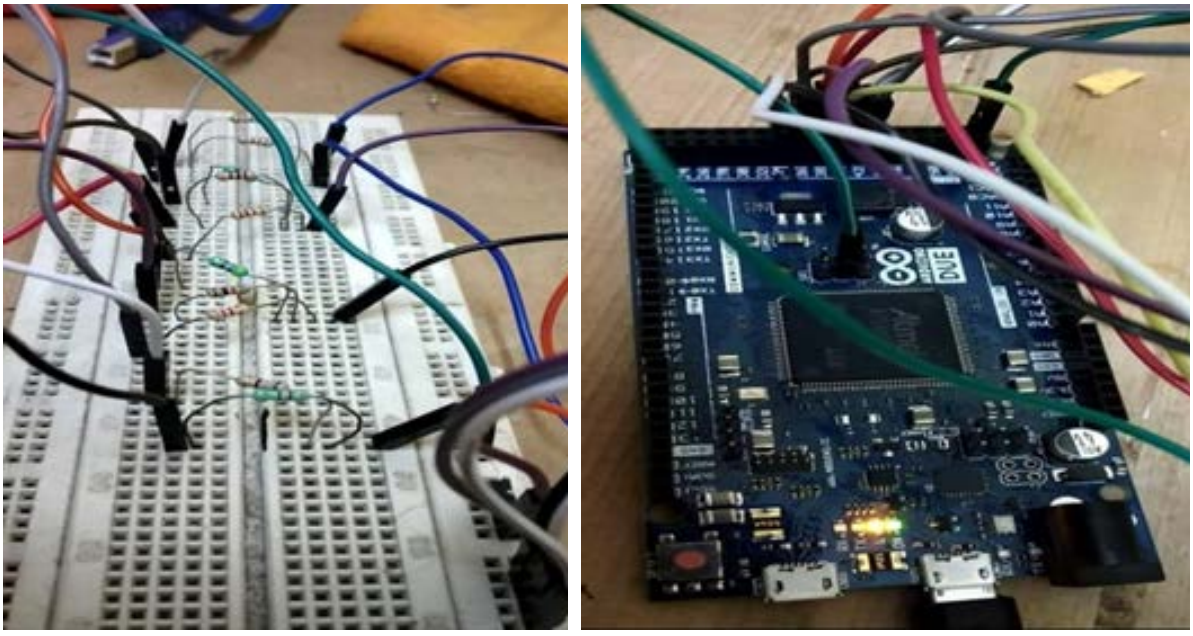

Figure 26-4 Circuit connection of VGA interfacing with Arduino Duo

Different Sensor for monitoring the air pollutant has been used which will provide the concentration of various gases. These consist of three air quality sensor, temperature and humidity sensor. The MQ series sensors used are

resistance based whose conductivity increases with the rise in the concentration of gases in air. Along with this Particulate Matter sensor have been used to measure the concentration of PM2.5 & PM10 which is laser driven. These sensors are low cost and are accurate, precise, small in size and microcontroller compatible.[18]Sensor's specification used to measure the concentration of pollutants is shown in tabular form.

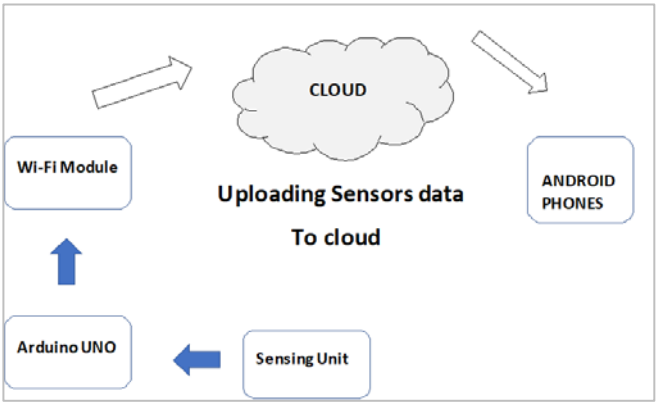

Figure 26-5 Block diagram of uploading data to cloud storage

Table 26-1 sensor's specification

Sensor	Sensing Gas	Operating Range
DHT22	Humidity & Temp	-40 - 125 C 0 - 100 %
SDS011	PM2.5 & PM10	0.0-999.9µg/m3
MQ7	CO	10 -10000ppm
MQ135	CO2, NH3, Benzene	10 – 1000 ppm

SDS011 is used to calculate the concentration of particulate matter in the atmosphere using a laser scattering technique. The low cost and precise size of this sensor made it suitable for use to sense air pollution by particulate matter emitted by traffic, building construction and industrial combustion.Concentration of PM gets influenced by several factors such as particle mass, chemical composition and shape as well. For the measurement stream of air is allowed to pass through the air channel to the measurement chamber. The light from laser diode get scattered and converted into electrical pulses, with the pulse area or height using transimpedance amplifier (TIA). After Analog to Digital conversion (ADC) through microcontroller embedded over it the pulse information is used to measure the PM values.

SOFTWARE ARCHITECTURE

Think Speak is an open source cloud platform provided for Internet of Things(IoT) by MATLAB analytics for uploading sensor data to the cloud in real time which means sensing and transmitting data at the same time. The provide features like storing, collecting, analyzing and visualizing sensor's data.

The result shows the monitored data of the different sensors after the final calibration of the sensors with microcontroller. mainly the air pollutants that are measured by the formed device are humidity, temperature, NH3, PM 2.5 and CO. The table below shows the monitored data of the specified pollutants by the microcontroller. The monitored data has also be shown on the VGA display that is connected to the microcontroller. The monitored

data is displayed on the VGA display for broadcast purposes and also in colorful figures. Below are the results of monitored data.

Figure 26-6 The monitored data on VGA display by interfacing with the microcontroller

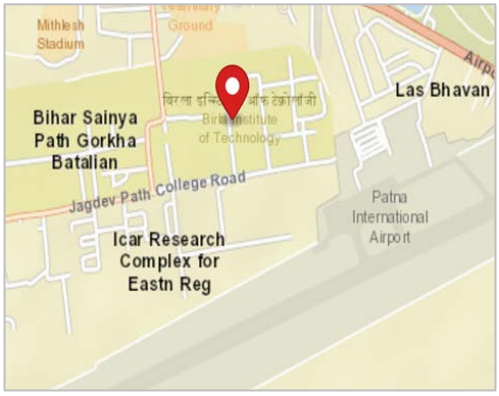

Figure 26-7 The figure shows the use of cloud to know the GPS location

Table 26-2 Sensor's Data

Date	Humidity (%)	Temperature (°C)	MQ135 (ppm)	PM2.5 ($\mu g/m^3$)	CO (ppm)
2019-07-27 20:15:57 IST	80	29	27	9	46.76141
2019-07-28 00:50:41 IST	78	28	27	9	46.55602
2019-07-28 00:52:46 IST	78	28	27	9	46.41908
2019-07-28 00:56:59 IST	78	29	28	9	43.95436
2019-07-28 00:59:05 IST	78	28	27	8	43.4751
2019-07-28 01:03:25 IST	79	28	27	2	43.4751
2019-07-28 01:05:31 IST	79	29	28	1	43.54357
2019-07-28 01:09:43 IST	79	29	27	10	43.74896
2019-07-28 01:11:49 IST	79	28	28	12	43.74896
2019-07-28 01:15:38 IST	77	29	28	12	41.3527
2019-07-28 01:16:41 IST	75	29	28	10	43.26971
2019-07-28 01:17:47 IST	76	28	27	12	42.58506
2019-07-28 01:18:50 IST	75	30	28	10	43.33817
2019-07-28 01:19:53 IST	74	30	28	12	43.33817
2019-07-28 01:20:57 IST	74	28	27	12	42.85892
2019-07-30 03:03:07 IST	65	29	28	12	42.65353

2019-07-30 03:04:13 IST	65	29	27	10	42.58506
2019-07-30 03:05:16 IST	65	29	28	12	41.83195
2019-07-30 03:06:20 IST	65	29	28	7	42.10581
2019-07-30 03:07:23 IST	65	29	27	13	41.21577
2019-07-30 03:08:26 IST	64	29	28	11	39.9834
2019-07-30 03:14:18 IST	66	30	27	13	41.3527
2019-07-30 03:15:22 IST	64	30	27	9	12.39212
2019-07-30 03:16:25 IST	63	30	27	11	44.98133

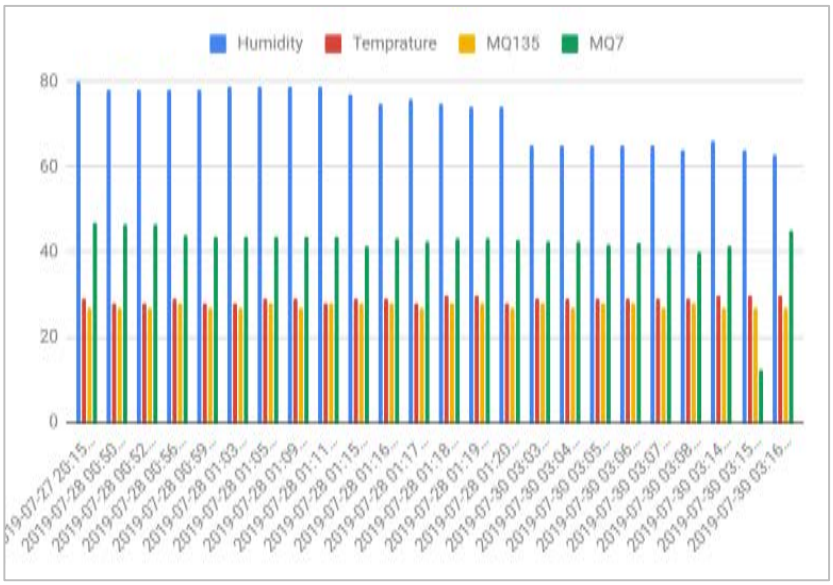

Figure 26-8 The graph shows the monitored data of air pollution monitoring device on the specified date and time in a graphical representation based on which Air Quality Index of the specific location can be calculated. The AQI can be displayed over the VGA display

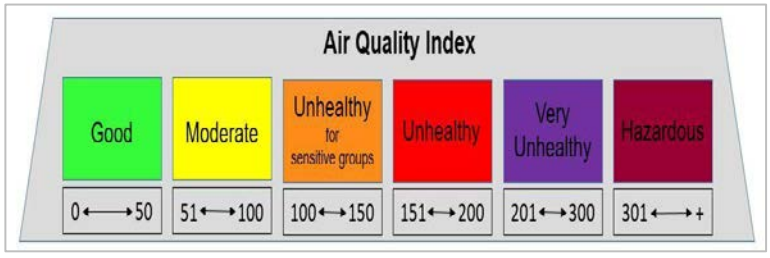

Figure 26-9 The below figure is the standard of Air Quality Index of the air. This shows the differentlevels of pollutants and their tolerance[17].

$$\text{Air Quality Index(AQI)} = \frac{\text{Pollution Level}}{\text{Pollution Standard}} * 100 \quad [20]$$

CONCLUSION

The device formed provides the monitored data of the air pollutants suspended in the atmosphere and sends the data over cloud in real-time for the user access. the device monitors the particulate matter, humidity, temperature and carbon monoxide suspended in the air. The results is been arranged in the tabular form. Based on the results it will be possible to get the information of change in the concentration of different air pollutants using the specified sensors. The sensor used in the prototype device is resistance and laser based sensors. A microcontroller computes the amount of air pollutants in the air and it is connected to the Wi-Fi module that sends the data to the server with the help of GSM module that provides the internet connectivity. The microcontroller used was NodeMCU. the microcontroller is connected to the VGA display that shows the data in representable and colorful format. Few sensors data cannot be displayed by the VGA displayed due to interfacing of the microcontroller through the resistance array. The users can easily check the real-time measurement via ThingView android application, along with the data of the past. The cloud platform also provides the graph of the monitored data for the visualization and interpretation of data.

REFERENCES

[1] Dhanashri Ajay konnur, Dr. L K Ragha, “Review Paper on Smart Sensor Network for Air Quality Monitoring”, International Journal of Innovative Research in Advanced Engineering, vol. 3, issue. 7, 2016.

[2] Professor Eddy Zeng, Professor Christian Sonne, “Environmental Pollution”, ELSEVIER.

[3] N. Paskin, “Toward unique identifiers”, IEEE explore, vol.87 , Issue. 7, 1999.

[4] Mutlu EA, Comba IY, Cho T, Engen PA, Yazıcı C, Soberanes S, Hamanaka RB, Niğdelioğlu R, Meliton AY, Ghio AJ, Budinger GRS, Mutlu GM, “Inhalational exposure to particulate matter air pollution alters the composition of the gut microbiome.”, Environmental Pollution, vol. 240, 2018.

[5] Swati Dhingra ; Rajasekhara BabuMadda; Amir H. Gandomi; Rizwan Patan; Mahmoud Daneshmand, “Internet of Things Mobile–Air Pollution Monitoring System (IoT-Mobair)”, IEEE Internet of Things Journal, vol. 6, issue. 3, 2019.

[6] Nihal Kularatna B. H. Sudantha, “An Environmental Air Pollution Monitoring System based on the IEEE 1451 Standard for Low Cost Requirements”, IEEE SENSORS JOURNAL, vol. 8, issue. 4, 2008..

[7] United Nations environment programme, “Air Pollution: Africa’s Invisible”, Silent Killer, 20 oct 2016.[online: https://www.unenvironment.org/pt-br/node/20803].

[8] N Künzli, R Kaiser, S Medina, M Studnicka, O Chanel, P Filliger, M Herry, F Horak Jr, V Puybonnieux-Texier, P Quénel, J Schneider, R Seethaler, J-C Vergnaud, H Sommer, H., “Public-health impact of outdoor and traffic-related air pollution: a European assessment”, The Lancet, vol. 356, pp. 795–801, 2000.

[9] Mage, D., Ozolins, G., Peterson, P., Webster, A., Orthofer, R., Vandeweerd, V., & Gwynne, M., “Urban air pollution in megacities of the world.”, AtmosphericEnvironment,vol. 30, pp. 681-686, 1996.

[10] Stuart L. Hart, “Beyond Greening: Strategies for a Sustainable World”, HARVARD BUSINESS REVIEW, 1997.

[11] WHO, “An estimated 12.6 million deaths each year are attributable to unhealthy environments”, WHO,2019.[online:https://www.who.int/news-room/detail/15-03-2016-an-estimated-12-6-million-deaths-each-year-are-attributable-to-unhealthy-environments.]

[12] A. R. Al-Ali ; Imran Zualkernan; FadiAloul, “A Mobile GPRS-Sensors Array for Air Pollution Monitoring” IEEE Sensors Journal, vol. 10, 2010.

[13] Wayne F. Berry, “VGA controller card”, US Patent 5 150 109, 1992.

[14] Benammar M, Abdaoui A, Ahmad SHM, Touati F, Kadri A, “A Modular IoT Platform for Real-Time Indoor Air Quality Monitoring.”,Sensors (Basel), vol. 14, 2019

[15] Borghi F, Spinazzè A, Rovelli S, Campagnolo D, Del Buono L, Cattaneo A, Cavallo DM, “Miniaturized Monitors for Assessment of Exposure to Air Pollutants: A Review”, International journal of environmental research and public health, vol.14, 2017.

[16] Jadhav D. A., Patane S. A., Nandarge S. S., Shimage V. V., Vanjari A.A, “Air Pollution Monitoring System Using Zigbee and GPS Module”, International Journal of Emerging Technology and Advanced Engineering, vol. 3, 2013.]

[17] The Minister for Environment, Forests & Climate Change Shri Prakash Javadekar launched The National Air Quality Index (AQI) in New Delhi under the Swachh Bharat Abhiyan, Oct 2014.[Online: www.cpcb.nic.in].

[18] Siby John , “Real Time Ambient Air Quality Monitoring System Using Sensor Technology, Jyoti Sharma”, Pec University Of Technology Chandigarh, 2018..

[19] Jadhav D. A., Patane S. A., Nandarge S. S., Shimage V. V., Vanjari A.A, “Air Pollution Monitoring System Using Zigbee and GPS Module”, International Journal of Emerging Technology and Advanced Engineering, vol. 3, 2013

[20] “Calculating a station air quality index”, EPA Victoria, 2015.[Online: https://www.epa.vic.gov.au]

[21] Rohizah Abd Rahman, Khairuddin Omar, Shahrul Azman Mohd Noah and Mohd Shahrul Nizam Mohd Danuri. A Survey on Mental Health Detection in Online Social Network, 2016.

[22] H. Appel, J. Crusius, and Alexander L. Gerla. Social comparison,envy, and depression on facebook: a study looking at the effectsof high comparison standards on depressed individuals. Journal of Social and Clinical Psychology, 2015.