International Journal of Recent Technology and Engineering (IJRTE)
ISSN: 2277-3878, Volume-8 Issue-4, November 2019

An Autonomous Air Pollution Monitoring System using IOT and Cloud

N. Susila, Esther Daniel, S. Durga

Abstract— Air pollution and its impact in the oceans and the terrain are in need of attention since it causes adverse effects in livelihood. Air pollutants identified so far produce destructive impacts to the human beings and the environment as well. The increase in toxic level reduces the capacity of the oceans to produce required oxygen which is a deteriorating factor. According to a recent report released by World Health Organization. 9 out of 10 people breathe the polluted air. Hence an efficient solution to monitor and control the air pollution is required. Recent trends in Internet of Things had helped in employing different gas sensors in order to identify the air pollutant levels. In this paper, it is proposed to develop a low cost system for efficient pollution monitoring and controlling. Integrated Internet of Things technology with Cloud services are employed to enable the effective services. Microsoft Azure's cloud services are used to store the inferred data which is used for further communication. The pollutant's toxicity level is identified and the system is alerted in order to control the air pollution. The system also uses the GSM / GPS module to track the location of high sensitivity within the selected zone. The toxic level of each type of pollutant is assessed. The main objective of the proposal is to observe, alert and control the air pollution.

Keywords : Air Pollution, Internet of Things, Air Quality Index (AQI), Cloud Computing.

I. INTRODUCTION

Air pollutants from factories, automobiles, institutional and residential are the major contributors for contaminations of marine waters. Pollution reduces the ability to produce oxygen. Nearly half of the oxygen comes from the oceans. The air pollutants such as nitrogen oxide, carbon monoxide, sulfur dioxide, dust particulate matter and ozone gas causes damage to our ecosystem. There is a crucial need for monitoring the air pollution level as the air quality reaches high toxic level causing harm to human beings and the environment. The major oxygen producers of the ocean are photosynthetic plants and bacteria. These water organisms are sensitive to the surroundings thus inhibiting their ability to produce oxygen due to drastic rise in temperature, pollutants and salinity. Atmospheric deposition can be caused by natural sources like forest fires and volcanoes but most of the air pollution are direct cause of irresponsible human activities. Nitrogen is vital for living organisms to grow but when in surplus stimulates enormous growth of plants and algae's thus depleting the oxygen levels. This nitric oxide emitted into the atmosphere is a by product of nitrogen gas released from vehicles, biomass burning and energy production. The airborne chemicals like carbon, nitrogen, Sulphur molecules fall into the ocean as the process of gravitational effect. Conventional air monitoring equipment's to monitor and control the air pollution are expensive, huge in size, complex and requires enormous human effort.

Internet of Things (IoT) connects things, people and cloud services via the Internet to enable sensors, actuators, monitors to oversee the environment for pollution in economical and effective way. Various sensors are used to calculate the toxicity level of harmful gases present in the air and based on the readings of the sensors the source of the pollutants is identified. The IOT based system can detect the pollution level in a particular area and predicts the outcome using prediction algorithms. Sensors combination also monitors pollution and detects the presence or absence of it. It uses NFC devices together and transfer data. The level of pollution can be collected so that we can monitor the pollution level from anywhere at ease and if there is any surge in the pollution level, an alert message will be sent to the respected authority. Hence the pollution monitoring and alerting system becomes very easy and efficient. Though the IOT based systems detects the pollution level, it has no integrated environment showing the levels of pollutants and also the systems which uses a Bluetooth support device to gather data from the sensors are probably short-range devices. Therefore, there is a crucial need for an air pollution monitoring system detecting the toxic level using sensors and processing the toxicity level stored on the web server to deliver accurate information for necessary measures to be taken to reduce them.

The rest paper is organized as follows. Section II details the related literatures. Section III explains the proposed IoT and cloud based autonomous air pollution monitoring system. The architecture and flow diagram of the proposed system are given in detail. Section IV reports the results and our observations. Section V concludes a work with few directions for further investigations

Manuscript published on November 30, 2019.
* Correspondence Author
Dr.N.Susila*, Dept of Information Technology, Sri Krishna College of Engineering and Technology, Kuniamuthur, Coimbatore – 641 008, Tamil Nadu, India.(Email: susila@skcet.ac.in)
Esther Daniel, Dept. of CSE, Karunya Institute of Technology and Sciences, Coimbatore, Tamil Nadu, India. (Email: estherdaniell@gmail.com)
S. Durga, Dept. of CSE, Karunya Institute of Technology and Sciences, Coimbatore,Tamil Nadu, India. (Email:durga.sivan@gmail.com)

II. RELATED WORK

The use of Arduino kit and the various air sensors in identifying the air pollution and the pollution level is updated in the website and an alert is sent to the respective are pollution control board as deliberated in [1]. The paper is focused on air and sound pollution. The system proposed in [2] provides an integrated model which combines IoT, ESP, Sensors and GPS. The pollution level identified is mentioned along with the location coordinates. The output observed is stored in thinkspeak cloud for later use. The results can be viewed through an android application for easy retrieval of data and necessary action. The various pollutant levels are observed and the area identified is updated in the Google Maps.

The proposed work handled the pollution monitoring in automobiles and discussed measures to control the pollution as described in [3]. The system also helped in routes' deviation where the quality of air is likely to be good. The system collects the pollutant levels from the sensors and thereby identifies the less polluted routes. The information is helped in regulating and rerouting the traffic to the less polluted routes and hence indirectly controlling the traffic in the highly polluted traffic routes. Environment adaptive calibration system proposed in [4] is employed along with the low cost electro chemical gas sensor to identify the air pollution based on different characteristics of air sensors. The focus is given to detect the air quality in outdoors based on various changes like climatic conditions, dust congestion etc. Raptor nodes are employed in monitoring the air pollutants such as NO_2 and O_3 . The results are analyzed using the metrological conditions like temperature, humidity and wind speed. The work proposed in [5] deliberated on the alarming system integrated with Internet of Things Technology to monitor and notify the air pollution caused thereby to effectively perform the risk management. The air pollutants are classified in two categories and their responses are measured under different weather conditions to determine the pollution level.

A model is suggested in [6] to conduct an analysis of the air quality and to forecast the quality of air and its pollutant level. Machine learning algorithm is employed for the assessment. The common air pollutants are considered for evaluation. The system analyzed the humidity and temperature and thereby determined the gas levels in the air. Data mining techniques like regression are employed in [6] to identify the pollutant levels released by different gases and the measures to monitor and control the air pollution. Multilayer perceptron is used to train the dataset in order to forecast the air pollution. Beagle Bone Board and Machine learning services of Microsoft's Azure Cloud are employed in the work proposed in [8] to position the location coordinates and to monitor the air quality in the selected area. The system also tried in reducing the air pollution level to a certain extent. The cloud database is synchronized updated periodically in concurrence with the internal database.

A low cost prototype is developed in [9] to monitor and disseminate the air pollution level of different gases. Mean stack is employed in communicating through the web. The different gas sensors are employed and raspberry pi 3 based server is utilized for the model. The model proposed in [10] used esp8266 to monitor and control the air pollution. The results are evaluated based on the smoke content, carbon monoxide and particulate matters PM1, PM2.5 and PM10. Different threshold levels are fixed for the different air pollutants and the experiments are observed and evaluated based on these levels.

III. IOT AND CLOUD BASED AUTONOMOUS AIR POLLUTION MONITORING SYSTEM

Air pollution is one of the environmental issues that cannot be ignored. Increase in pollution in recent years is manifold. The people are unaware about the growing impact of pollution and increase in several pollutants level in the air. There is a lack of proper monitoring system in localities where pollution is increasing and the traditional air pollution and detection monitoring methods are typically expensive. Therefore, a low-cost integrated system to alert people of the increasing toxic level in air is required. The main objective of this paper is to develop an application which is the combination of software and hardware that is used for sensing, processing and alerting the environment about the toxicity levels present in the air. This system will determine status and trends of ambient air quality and make normal people aware about the total pollutants and its sources. The information about the toxicity level of each pollutant is detected individually in PPM. The main aim of this paper is to alert the environmentalists about the rising dangers of air pollution.

Introducing a system which is the combination of software and hardware that is used for sensing, processing and alerting the environment about the toxicity levels present in the air. It is an application to make normal people aware about the total pollutants and its sources. It aims to develop an application that can monitor certain atmospheric components and transfer the data continuously for the display in order to determine status and trends of ambient air quality. It detects the toxicity level of each pollutant individually in PPM and alerts the environmentalists about the rising dangers of air pollution using GSM/GPRS module. The major contribution includes detecting the toxic level using sensors and processing the toxicity level. The sources of the pollutant are correlated and the pollutant data is stored in the web server. The advantages of the system are:

1. System is real time and the sensors have long lifetime.
2. The installation cost of the system is comparatively less compared to the othersystems.
3. It is simple, compact and easy tohandle.
4. The application is interactive, user friendly and provides a visualoutput.
5. Accurate measure of the toxicity level of each pollutant is detected individually inPPM.
6. The data is stored in the database in order to extract information for futureuse.

A. System Architecture

The system is monitored through the web application as a whole.

The data from the three sensors are collected at regular interval of time and processed in Arduino and converted into their unitsand sent to the database through
GSM/GPRS module for storing which can be helpful for generate reports and statistics. The stored data can be accessed anytime from the database through web application and the report can be generated. The live data can be simultaneously stored in the database and can be viewed through the web application. The system architecture is depicted in Fig. 1.

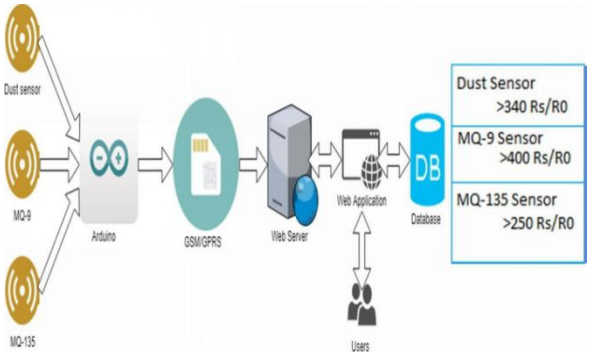

Fig. 1. System Architecture

The first step involved is sensing the environment through sensors. All the data's which recorded by the sensors at regular intervals are Raw data and those Raw data's have to be converted into their respective units. The data recorded by Dust sensor is converted into micro- grams/cubic meter and the data recorded by MQ-9 and MQ-135 are converted into PPM. This is followed by the second process to send the converted data to database through web server using GSM/GPRS Module for storing them. The data's stored in the database can be retrieved anytime through web application for the report generation and statistics as per the conditions/range set by the user. The data flow diagram as shown in Fig. 2 demonstrates a complete workflow of the entire process.

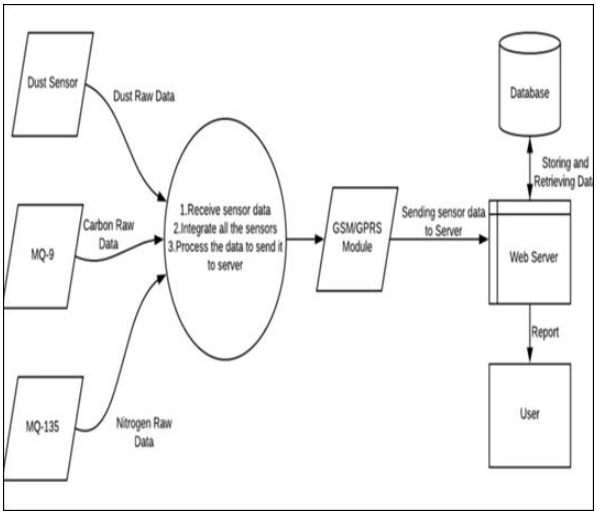

Fig. 2: Data Flow Diagram

SENSING THE ENVIRONMENT (SENSORS):

The sensing of environment is done by the sensors namely Dust, MQ-9 and MQ-135 which used to sense the pollutants such as dust, carbon and its constituents and nitrogen and its constituents respectively. Sensing is done at a regular interval of time and those sensed data are sent to the Arduino simultaneously for processing. The data's recorded by the sensors are raw data which have to be processed.

PROCESSING THE SENSOR DATA (ARDUINO):

The raw data received from the sensors are processed in the Arduino. Processing done here is converting the raw data into their respective units. The data recorded by Dust sensor is converted into micro-grams/cubic meter and the data recorded by MQ-9 and MQ-135 are converted into ppm. The processed data have to bestored.

The processed data have to be stored in the database. So, the data have to be travelled from the Arduino to the database. For that, a GSM/GPRS Module is used for the transportation of data. The processed data is sent to the GSM/GPRS Module and the module sends the data to the database.

STORING THE POLLUTANT DATA (WEB-SERVER):

The data from the GSM/GPRS Module is stored in the database for the future use. The stored data can be used for report generation and statistics. The data can be retrieved anytime from the database through web application.

IV. RESULTS AND DISCUSSION

The proposed system has been developed and tested in various places at Coimbatore city and the samples were collected and then analyzed to find the quality of the air in and around Coimbatore.MQ135 gas sensor is highly sensitive to harmful gases such as Ammonia, Sulphur, Benzene and smoke. The Dust Sensor is an optical air quality sensor designed to sense the dust particles. The MQ-9 *g*as sensor is useful to sense gasses like Carbon Monoxide, Methane and LPG in the air. The voltage produced by the sensors increases as the smoke or gas particles in the atmosphere is sensed. The sensor voltage is proportional to the concentration of the gas and smoke in the air. Fig.3 shows that the hazardous gas levels in the atmosphere are moderate as it is increased above the threshold level.

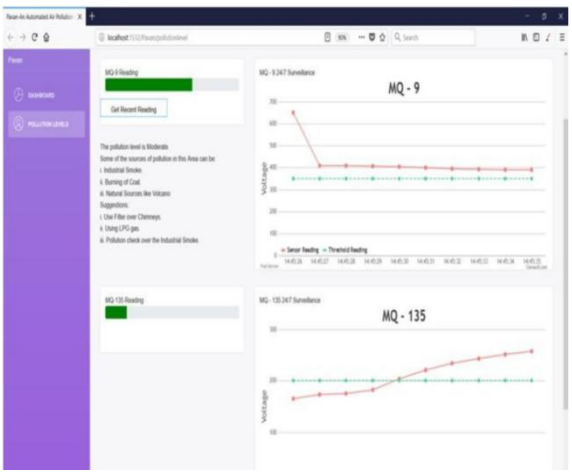

Fig. 3 : Sensor Readings and toxicity levels of hazardous gases

Table 1. AQI at various places

Area	Type	Average Statistics week 1	Average Statistics week 2	Average Statistics week 3
City Center	Mixed	79	102	115
Housing Unit	Residential	30	69	73
SIDCO	Industrial	35	85	113
Shopping Malls	Commercial	42	77	101

The pollution level is gradually increasing from good to moderate levels. The air quality level below 50 will have lower risk of pollution and when it increases from 50 to 100 the pollution level is moderate and more than 100 the API level is satisfactory. The test case results show that there is a gradual increase in the pollution in the city and so it is important to have controlling mechanism to minimize it. If uncontrolled it produces unhealthy air and serious risks to the environment and people around. O3 generators for fresh air can be installed and reduce the risks involved.

V. CONCLUSION AND FUTURE WORK

Pollution prevails to be a life-threatening problem that the whole world faces and hence it becomes a priority where everyone has to be aware of the growing danger in the locality. Thus the proposed system provides user friendly approach towards the environmental education. It can clearly detect and alert the sudden rise in toxic level of air with proper measures and guidelines. Thus the proposed system proves to be an intelligent approach towards the protection and prevention of air pollution hazards met in the future. The proposed system becomes an integrated system where the measure of pollutant levels can be identified uniquely for each pollutant and can be improved over the effects of toxicity in air and the vulnerability of the locality to pollution.

The proposed system may be extended by applying machine learning algorithms to estimate and foresee the toxic level in air. A mobile application integrating with the web page to provide instant access to the pollution data level can be deployed. The strategies to transform the air pollution into a nontoxic air can be identified and employed. Data analytics algorithms can be employed to handle the data when it grows in manifolds.

REFERENCES

1. Poonam Pal, Ritik Gupta, Sanjana Tiwari and Ashutosh Sharma, 2017, "IOT Based Air pollution monitoring system using Arduino", International Research Journal of Engineering and Technology, Vol.4, Issue:10, Oct 2017, pp. 1137 –1140
2. G. Spandana and R.Shanmugasundaram, 2018, "Design and Development of Air Pollution Monitoring System for Smart Cities", Proccedings of the Second Int. Conf on Intelligent Computing and Control Systems, IEEE Xplore 2018, pp. 1640 –1643.
3. S.Muthukumar, Sherine Mary, Jayanthi, Kiruthiga and Mahalakshmi, 2018, "IOT Based Air Pollution Monitoring and Control System", Proceedings of the Int. Conf on Invention research in Computing Applications, ICIRAC 2018, IEEE Xplore, pp. 1286 – 1288.
4. Bin Tian, Kun Mean Hou, XunxingDiao, Hongling SHI, Haiying Zhou and Wei Wang, 2019, "Environmental Adaptive Calibration System for Outdoor Low Cost Electrochemical Gas Sensors", IEEE Access, Vol.7, May 2019, pp. 62592 –62605.
5. Anwar Alshamshi, Younas Anwar, Maryam Almulla, Mouza Aldhohoori, Nasser Hamad and Mohammed Awad, 2017, "Monitoring Pollution: Applying IoT to create smart environment", 2017 International Conference on Electrical and Computing Technologies and Applications (ICECTA), IEEE Xplore,2017.
6. TemesegenWalelignAyele and Rutvik Mehta,2018, "Air Pollution Monitoring and Prediction using IoT", Proceedings of the 2nd International Conference on Inventive Communication and Computational Technologies (ICICCT 2018), IEEE Xplore, 2018, pp. 1741 –1745.
7. Shweta Taneja , Nidhi Sharma, Kettun Oberoi and Yash Navoria, 2016, "Predicting Trends in Air Pollution in Delhi using Data Mining", 1st India International Conference on Information Processing(IICIP).
8. Nitin Sadashiv Desai and John Sahaya Rani Alex, 2017, "IoT based air pollution monitoring and predictor system on Beagle Bone Black", 2017 International Conference on Nextgen Electronic Technologies, IEEE Expore, pp. 367 –370.
9. Gagan Parmar, Sagar Lakhani and Manju K. Chattopadhyay, 2017, "An IoT Based Low Cost Air Pollution Monitoring System", Proceeding International conference on Recent Innovations is Signal Processing and Embedded Systems (RISE-2017) October,2017, pp. 27-29.
10. Setiawan, F.N. and Kustiawan, I, 2017, " IoT based Air Quality Monitoring", International Symposium on Materials and Electrical Engineering (ISMEE) 2017, IOP Conf. Series: Materials Science and Engineering pp. 384 –393.