Real Time Air Pollution Management Monitoring System for Metropolitan Cities

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Abstract : Increased urbanisation has increased the number of vehicles on road exponentially causing an exponential growth in air pollution booming the health risk and affects the environmental factors. Hence, tracking quality of air that is polluted for further action. Transportation is the major source of $N0_2$ emission in air resulted in the vulnerable global challenges faced and its effect on climate with deteriorating air quality. Although, various technologies are available for monitoring air pollution, the proposed system provides real time monitoring of air pollution by deploying sensors in urban areas using UAV with data collected and monitored by the main control system. In case, the pollution level exceeds the threshold value set before, system raises alarm to block the traffic or allow minimum traffic on that path to prevent pollution disaster at that area under consideration.

IndexTerms **- Air Pollution; UAV; monitoring cell; NS-2; Wireless Sensor Network (WSN).**

I. INTRODUCTION

In recent development of urban areas there is a concern about the simultaneous increase in pollution levels with the increased usage of vehicles. A report from the Regional Transport Office, Bangalore present 77,95,465 total vehicles were registered in the city till October 2018. Bangalore is honoured to have the largest number of two-wheelers in the country. The inadequate road system and enormous increase in number of vehicles have precipitated to problem of traffic thrombosis in the city. Inadequate bus services led to the proliferation of auto-rickshaws in the city that are multiplying at an alarming rate, causing traffic congestion, road safety problems, noise and air pollution. Recently, released data by Central Pollution Control Board (CPCB) of Bangalore [1] recorded the second worst pollution due to road dust and vehicle emission, beating the highly polluted Delhi. Furthermore, it has become ever more expensive for monitoring and mapping the pollution levels across the city due to densely crowded population and commercial areas that contribute to environment pollution. Hence, an effective economically viable solution to this problem of monitoring pollution is being proposed.

Advancement in the technology of wireless communication and sensor networks that have contributed a wide range of applications in environmental monitoring, pollution control. In today's world Pollution detection and control are the major research issue going on. Detailed study on ambient air pollution monitoring and air quality in metro cities using sensor nodes in a wireless sensor network is discussed, mainly focusing on how a sensor network is used in a wide range to monitor the air pollutants such as CO2, NO2, SO2, PM, NH3 and other toxic gases present in an urban ambient place is major human activities. Role of WSN in air and pollution monitoring involves deployment of sensor nodes in a large scale at very low cost, to collect the real-time data for producing accurate results.

An alternative solution is hence required to reduce the air pollution, Fig.1, Ambient Air Quality Monitoring (AAQM) depicts air pollution in Bangalore, India [2]. The pollution level is collected by Unmanned Aerial Vehicle (UAV) which is revolving around and passes information to the monitoring cell.

The monitoring cell processes and updates the information in the database received from UAV and this data is received from the sensor. In case the pollution level is above the threshold level, UAV controls the traffic signal on that particular path and restrict until the pollution comes below the threshold level.

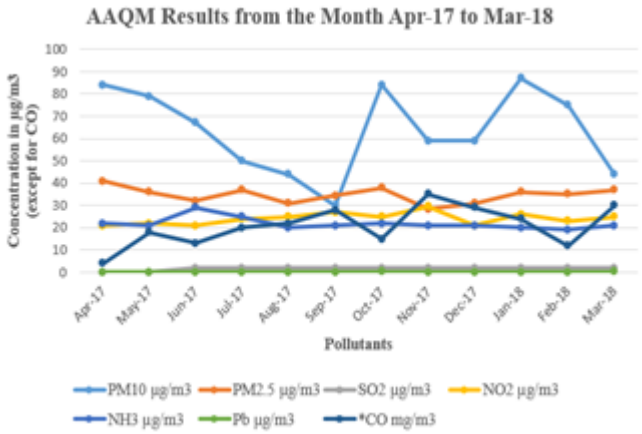

Figure 1. Ambient Air Quality Monitoring of Bangalore, India from the month April 2017 to March 2018.

II. LITERATURE SURVEY

S.P. Mahendra and K. Murthy presented a survey that shows that 60 % of air pollution in the cities are due to automobile exhaust emissions. Vehicles directly discharge its emissions into the breathing zone. Motor vehicles possess the greatest air

pollution potential as compared to other sources because more numbers of vehicles are congested in urban areas and the quantity of pollutants they emit, causing various adverse effects on human health and environment too [3].

Pratima Gupta and Ranjit Kumar et al., Air pollution is a major issue to deal with as it spans across multiple sources from vehicular emission, suspended dust, industrial plumes, construction material, waste burning. Domestic heating and cooking. reduction of emission can be achieved by use of better technology through modification and replacement of existing equipment includes less use of fossil fuels. Hence, the reduction of dependencies on the fossil fuels must be considered. Lastly, the step of implementation and execution is most important as whole model depends on the successfulness of this step [4].

Sabri Ghazi et al., proposed a Gaussian Plum air pollution dispersion model (GPD) combined with an Artificial Neural Network (ANN) that predicts the concentration levels of three different air pollutants. GPM and ANN are integrated with a MAS (multi-agent system). The population of agents cooperates with each other reduce their emissions and control the air pollution. Leaks or natural sources of pollution are modelled as uncontrolled sources. A cooperation strategy is simulated and its impact on air pollution evolution is assessed and compared. The simulation scenario is built using data about Annaba (a city in North-East Algeria). The simulation helps to compare and assess the efficiency of policies to control air pollution during crises, and takes in to account uncontrolled sources [5].

Sonal Deshmukh, Aditya Jagtap et al., collected gas data and vehicle data. Clustering is applied to predict whether Traffic is more or not on vehicle data. In case, the Traffic is more, instruction is passed to controller for adjusting time of traffic signal that helps in managing traffic & avoiding congestion. Mobile users can retrieve real time information for their use with internet. End user or client may request to server via Android Application for knowing the real time situation about traffic & air quality of remote location. Ultrasonic waves sensors that gives accurate reading for the estimation of vehicle count are little bit costly and robust for any medium through which waves can passed. RFID tag and Reader more reliable for the use of measuring vehicle density and for accuracy too. In the smart city each vehicle having RFID tag and at the Traffic Signal reader would be more communicative in nature for exchanging their messages. On the basis of data for Vehicle density and air quality prediction for future condition can be done using Various Predication Algorithm reducing many problems [6].

Abdullah Kadri, et al., presented an end-to-end system for ambient real-time air quality monitoring and prediction. The system contains two main components, the multi gas monitoring stations and the M2M platform. Four solar powered multi gas monitoring stations have been deployed and the data have been collected for four months, cleaned, and analysed. The monitoring stations communicate using GPRS in a M2M fashion with a backend server. To allow personal access to the data by the authorized person Web and mobile applications have been developed. It also includes the use of prediction algorithms based on neural networks in order to estimate pollution information in the near future. In addition to this prediction in time and space is also an interesting research topic, it would be interesting and challenging to estimate the pollution levels over the whole area of interest [7].

III. Background

Traffic jamming increases average air pollution at peak hours. At low speeds, scientific studies disclose that the vehicles burn fuel uneconomically and pollute more per trip.

A. Wireless Sensor Network

Wireless Sensor Network (WSN) is finding enormous field of research due to its broad applications including the field of environmental monitoring and pollution control through deployment of sensor nodes at a low cost and higher functionality in a wide area. An intelligent smart sensor network with several sensor nodes can gather and process a large amount of data starts from the monitoring to manage air quality, the traffic conditions, and weather stations. WSN consists of sensor nodes containing simple processors, low power consuming antennas and various detectors. As the sensor networks do not require wired communications infrastructures, they can easily and inexpensively be deployed without harming the environment. The need to monitor and safeguard environment is a key development of urban places and metropolitan cities where the population is more and major cause for the pollution. Air pollution monitoring (APM) is major discussion for urban environmental monitoring (UEM) and central pollution control board (CPCB). One of the main features of a sensor node in a sensor network is its low-power consumption and multi-functionality. WSN serves as a lone contender of technologies for UEM in metro cities that gathers large amount of real time data and process all sorted data accurately and provide sensible information with respect to air pollution in real time. WSN consists of spatially distributed autonomous sensors to monitor physical or environmental conditions and to cooperatively pass their data through the network to main location. [7]. Each sensor node in network is consumes low-power and having multi-functional feature WSN have been widely used and applied in other fields too like military applications, industries, medical and health care, agriculture and habitat monitoring.

B. IEEE 802.11p and IEEE 1609 Standards

IEEE 802.11p is an approved amendment to the IEEE 802.11 standard to add Wireless Access in Vehicular Environments (WAVE), a vehicular communication system. It defines improvements to 802.11 (the basis of products marketed as Wi-Fi) required to support Intelligent Transportation Systems (ITS) applications. This includes data exchange between high-speed vehicles and between the vehicles and the roadside infrastructure, so called V2X communication, in the licensed ITS band of 5.9 GHz (5.85-5.925 GHz). IEEE 1609 is a higher layer standard based on the IEEE 802.11p which is also the basis of a European standard for vehicular communication known as ETSI ITS-G5. IEEE 802.11p allows stations to synchronize themselves with a common time reference. It describes a way to exchange data through that link without the need to create a basic service set (BSS), without the need to wait for the association and authentication procedures to complete before exchanging data. For that purpose, IEEE 802.11p enabled stations use the wildcard BSSID [8] in the header of the frames they exchange and start sending and receiving the data frames once they arrive on the communication channel. IEEE 802.11p standard typically uses channels of 10 MHz bandwidth in the 5.9 GHz band (5.850-5.925 GHz). This is half the bandwidth, or double the transmission time for a specific data symbol, as used in 802.11a. This allows the receiver to manage better with the characteristics of the radio channel in vehicular communications environment.

C. Dijkstra's Algorithm

The algorithm is a graph based search algorithm that provides the shortest path solution for the single source graph with positive edge costs by generating shortest path tree[8]. The routing algorithm finds the lowest cost path between the source and other nodes, resulting in the shortest path between the source and destination nodes. It has wide range of applications in network routing protocols like Open Shortest Path First (OSPF).

D. Ad-Hoc On Demand Distance Vector Protocol (AODV)

It is a responsive protocol whose which is carried out by Route Discovery Cycle (RDC) maintaining active routing. It is a successor of DSDV protocol providing unicast and multi-cast communication [8] adding an extra feature of sequence number to prevent loop formation. AODV is well-known for its quick adaptation under dynamic link conditions using less network bandwidth which is scalable for larger network.

E. Destination Sequenced Distance Vector Protocol (DSDV)

It is a Bellman-Ford algorithm which is used to solve the routing loop problems by adding sequence number. DSDV results in better performance [8] with fewer nodes and adequate mobility. Regular updates of its routing tables is the major hindrance for its performance in dynamic environments and large network.

F. Unmanned Aerial Vehicle(UAV)

An UAV is widely identified by drone, which is an aircraft without a human pilot on-board. It is a part of an [9] Unmanned Aircraft System(UAS) includes an UAV and ground-based controller, which builds a communication system between the two. The trip of UAVs work with different conditions, either under remote control by a human administrator or independently by on-board computers. UAVs are substantially more powerless to climate changes since they fly low. Automaton advocates imagine a future in which swarms of UAV will be in travel or performing assignment, so information about their traffic management will be a key to movement administration. That navigation route will require something other than a fundamental street map. Notwithstanding areas of physical buildings, navigation systems additionally need to get dynamic information data that changes progressively and empowers UAVs to avoid hazardous or limited zones that can incorporate changing environment factors.

G. NS-2

Network simulator is built using C++ and Python script capability. Each element is denoted as node. Nodes can be dynamic or static according to the requirement. Communication is established between the nodes with TCP, UDP, CBR, FTP [9] links. It is economical as it doesn't require costly equipment. It supports communication protocols. Complex scenarios can be tested easily in this simulator. Results can be quickly obtained – more ideas can be tested in smaller time frame.

IV. POLLUTION MANAGEMENT SYSTEM

The Air Pollution Monitoring Management System aims at reducing the air pollution below the threshold level. Initially the drone collects the sensed information and the monitoring cell processes accordingly.

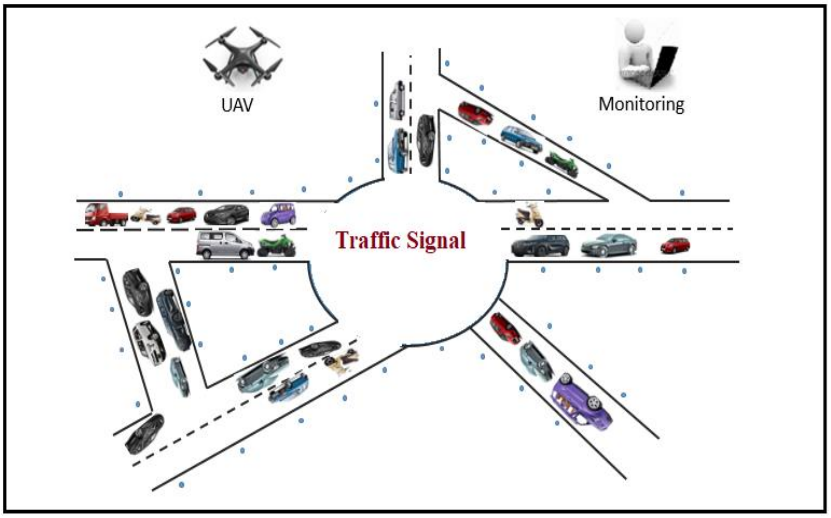

Figure 2. Monitoring of Air Pollution Architecture

A. Vehicular Movement

The high density vehicular movement in the causes the pollution and as the vehicular movement is continuous, the pollution level will be varying at the place.

B. UAV Movement

Firstly, the movement of drone is necessary to capture and collect the information from the sensors placed around an identified place. The drone collects the information from the sensors and then updates the monitoring cell (where the data base is available). Once the processing is done in the monitoring cell, the drone will be updated by the information available in monitoring cell and collected information of the drone is given to the receivers. The movement of the drone is continuous around the selected area throughout the period.

C. Block Path

At the peak hours, the volume of vehicles will be more, thus pollution level goes beyond the threshold level. This information is sensed by sensors and collected by the UAV respectively. In turn the sensed information of sensors by UAV is given to monitoring cell, processing is UAV by it. Then the processed data is passed to the UAV and received by the receiver. As one sensor gets information about the occurrence of pollution, the corresponding sensors will also turn red, because upcoming vehicles should be restricted in order to manage the pollution level, because it may cause severe damage to the environment, health issues for human.

D. Diversion

The path that is connected to the is blocked unless the pollution is below the threshold level across the place. The vehicles that are restricted to pass are allowed to take the diversion to reach the destination. After clearance of road, automatically the pollution level drops below the threshold level, facilitating the restricted or blocked road free for the vehicles to move.

E. Sensor

Different types of sensors are available for collecting the atmospherically data like Temperature sensor, Humidity sensor, Rain sensor, Gas Sensor etc. The pollutants like CO_2, NO_2 and SO_2 is detected through sensors. The sensors collect the different gases from road traffic emission. Additional sensors may enhance the network and monitoring the additional pollutants. Sensors are deployed in several cities to monitor the concentration of dangerous gases in the cities, the data are presented in the friendly format to create awareness among the people and to take appropriate measures to control it whenever it is needed.

V. PERFORMANCE EALUATION AND ANALYSIS

Vehicles equipped with communication devices can act together efficiently by exchanging the information of congestion with dispatch center and other neighboring vehicles and making it possible for the vehicles to travel in co-ordination and giving way for ambulance.

The Wireless Sensor Networks (WSN) have fascinated a lot of academic and industrial researchers due to its lesser maintenance, low price and used in widespread applications such as industrial, health and military.

The typical WSN based Air Pollution Monitoring Management System(WSN-APMMS) applications are Information Gathering, Data Transmission, Processing of Data to plan the required activities, Implementation with appropriate actions.

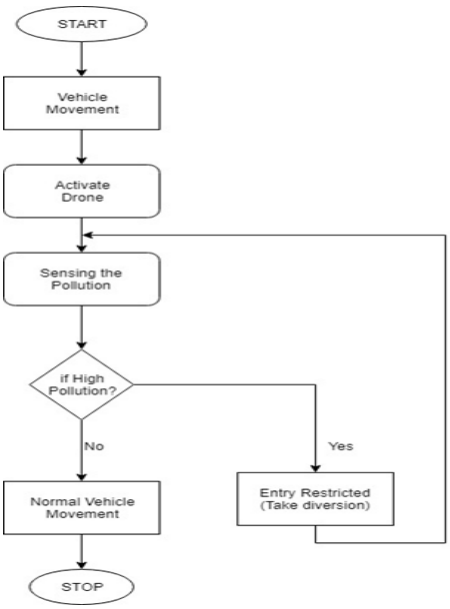

Figure 3. Flow chart of Air Pollution Monitoring Management System

Measuring gases for air quality monitoring is a challenging task that claims a lot of time of observation and large number of sensors. The aim is to develop a partially autonomous UAV equipped with sensor, in order to monitor and collect air quality real time data in designated areas and send it to the UAV. This is designed and implemented by employing two methods. The first method is responsible for implementing air quality sensors for detecting real time data and transmits it from the sensor to the UAV. On the other hand, the second method takes care of manipulating the data. The proposed work contains several sensors to measure Temperature, Humidity, Dust, CO2 and O3 and the collected data is transmitted to UAV over internet.

A WSN offers a very good solution for the design and development of traffic control system applications which consecutively deals with the air pollution monitoring application. The sensor network comprises of a sensor to monitor air quality in an allocated area and this information is collected by UAV node to direct the same to the monitoring cell called Base

Station (BS). The APMMS is used to carry out these functions independently with the help of wireless sensors, monitoring cell and UAV.

The movement of UAV is necessary to capture and collect the information from the sensors placed at the location. The UAV collects the information from the sensors and then updates the monitoring cell (where the data base is available). Once the processing is UAV in the monitoring cell, the UAV is updated and it provides the information to the receiver placed next to the sensor. The movement of the UAV is continuous around the selected area throughout the period.

The high density vehicular movement in the causes the pollution and as the vehicular movement is continuous, the pollution level will be varying at the place. The pollution level is sensed by the sensors.

The sensor senses the pollution level where the threshold level is fixed. And all the sensed data is received by the UAV that is continuously revolving around the circle. The information is then updated to the monitoring cell where the data base is available. The processing is UAV in the monitoring cell by using the data base.

The sensed information will be collected by UAV which in turn will be given to the monitoring cell which processes the given information available by UAV. The collected information from the monitoring cell is given to UAV and is followed by the receiver.

Initially in early morning, the pollution is less, as because very rare vehicles will be moving on roads so that collected data by UAV which in turns will be directed towards monitoring cell which processes the available information from the UAV. The manipulated data from the monitoring cell is given to UAV followed by the receiver which is placed very next to the sensor.

At peak hours, the volume of vehicles will be more, thus pollution level goes beyond the threshold level. This information is sensed by sensors and collected by the UAV respectively. In turn the sensed information of sensors from UAV is given to the monitoring cell, processing is done by it. Then the processed data is passed to the UAV and collects data by the receiver. As one sensor gets information about the occurrence of pollution, the corresponding sensors will also turn red, because upcoming vehicles should be restricted, in order to manage the pollution level, because it may cause severe damage to the environment, health issues for human.

The path that is connected to the is blocked until the pollution is below the threshold level across the place. The vehicles that are restricted to pass are allowed to take the diversion to reach the destination. After clearance of road, automatically the pollution level drops below the threshold level, facilitating the restricted or blocked road free for the vehicles to move normally.

IV. SIMULATION RESULTS

Experimental Analysis:

To simulate the multiple scenarios of wireless network, a TCL program is written in NS2 and related parameters depicts in Table I.

Table I: Simulation Related Parameters

Channel Type	***Wireless***
Radio-Propagation Model	Two-Ray Ground
Network Interface Type	Wireless Phy
MAC Type	Mac/802.11
Interface Queue Type	Queue/Drop Tail/Pri Queue
Antenna Model	Antenna/Omni
Link Layer Type	LL
Max packet in ifq	50

The nodes serve as traffic signals at respective places alternating red, yellow and green color, nodes with black, blue, orange, serve as vehicles.

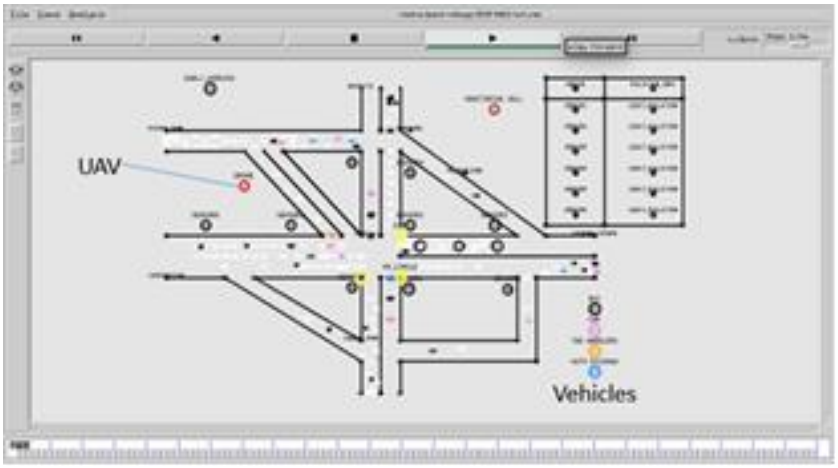

Figure 4. Snapshot Map with less pollution in early morning

The pollution is below the threshold level, Figure 4. Hence the sensors are in the same colour. There is no effect at this time

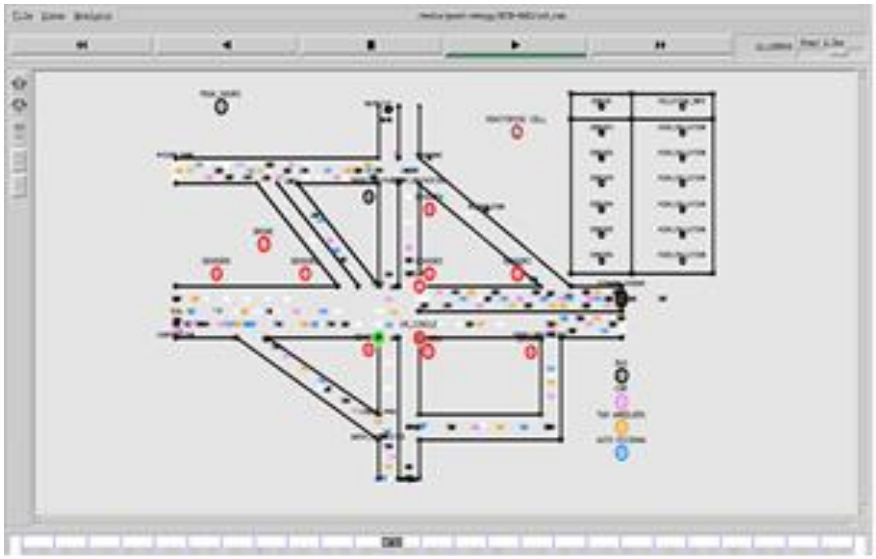

Figure 5. Snapshot of High Pollution Detected in Peak Hours

The road connected to the is blocked, Figure 5 since the pollution is high. To reduce the pollution, the path is blocked and the vehicle movement is stopped or else the diversion is allowed as shown

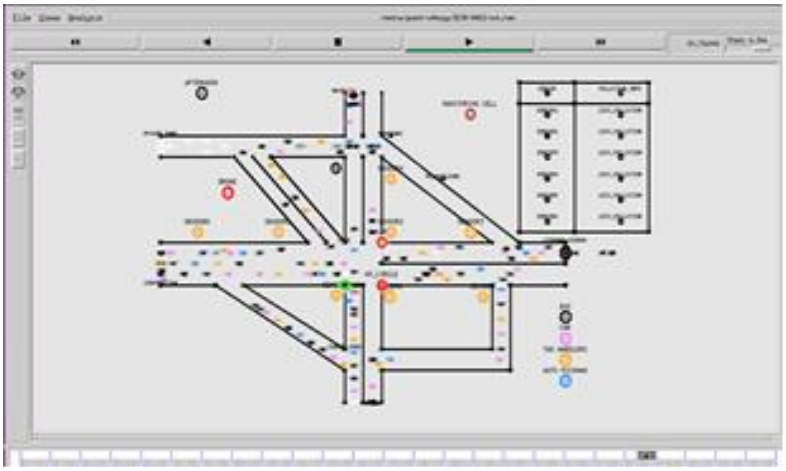

Figure 6. Snapshot of Entry Restricted

The road of is cleared and the vehicles are not allowed to pass in that place. Therefore, the place is now free from the vehicles causing high pollution. Here the pollution sensed by the sensors is below the threshold level. Therefore, the colour of the sensor changes to original. Here the vehicles are moving normally.

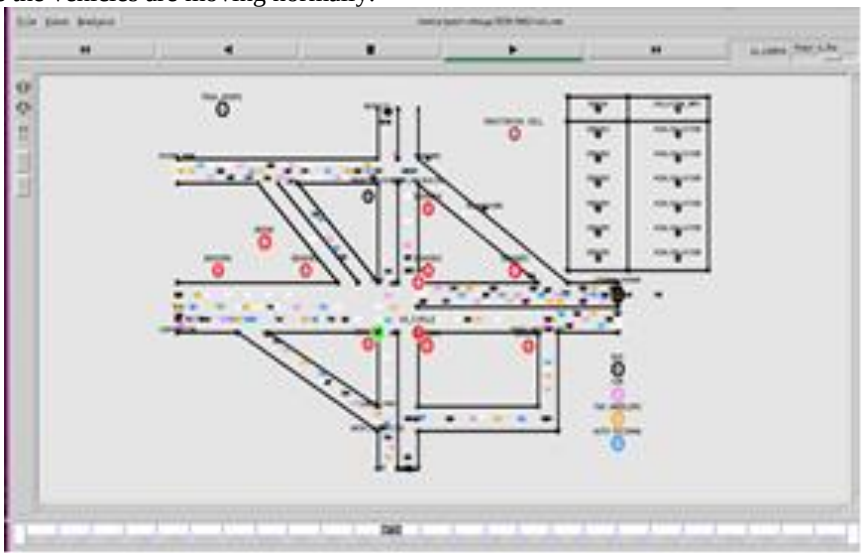

Figure 7. Snapshot of Vehicles taking Diversion

The road of is cleared and the vehicles are not allowed to pass in that route. Therefore, the allocated location is now free from the vehicles causing high pollution. Here the pollution sensed by the sensors is below the threshold level. Therefore, the colour of the sensor changes to original. Here the vehicular movement is normal.

VI. CONCLUSIONS

In recent years, the developments in the field of electronics and wireless communication technology have led to the development of Environmental Sensor Networks. These will significantly increase in monitoring the environment and explore new techniques to achieve higher accuracy compared to traditional sensors.

The sensors provide real time information about air quality, along with alerts in cases of extreme change in air if any. The obtained information is then collected by the authorities to take speedy actions such as blocking the path and taking diversion to reach destination.

REFERENCES

[1] CPCB (1996/97), Pollution statistics on Bangalore, Bangalore.

[2] https://www.kspcb.gov.in/ambient_air_quality.html

[3] S.P. Mahendra, K. Murthy, "Vehicular pollution in Bangalore: an overview", WIT Transactions on State of the Art in Science and Engineering, Vol 22.

[4] Pratima Gupta and Ranjit Kumar, "A study on monitoring of air quality and modeling of pollution control", IEEE Region 10 Humanitarian Technology Conference, India 2016.

[5] Sabri Ghazi, Julie Dugdale, Tarek Khadir, "Modelling Air Pollution Crises Using Multi-agent Simulation", 49th Hawaii International Conference on System Sciences, pp 172-177, 2016.

[6] Sonal Deshmukh, Aditya Jagtap, Sameer Inamdar, Ganesh Mahadik, "Real Time Traffic Management and Air Quality Monitoring System Using IoT", International Journal of Innovative Research in Computer and Communication Engineering, Vol. 4, Issue 4, April 2016.

[7] Abdullah Kadri, Elias Yaacoub, Mohammed Mushtaha, and Adnan Abu-Dayya, "Wireless Sensor Network for Real-Time Air Pollution Monitoring", 2013 1st International Conference on Communications, Signal Processing, and their Applications (ICCSPA), Sharjah, United Arab Emirates, 2013.

[8] Efficient Narendra Kumar G., Chandrika Swamy, and K. N. Nagadarshini, "Efficient Garbage Disposal Management in Metropolitan Cities Using VANETs", Journal of Clean Energy Technologies, pp 258-262, Vol. 2, No. 3, July 2014.

[9] Vesela Todorova, "UAE released 200m tonnes of greenhouse gases in 2013", http://www.thenational.ae/uae/environment/uae-released-200m-tonnes-of-greenhouse-gases-in-2013, January 21, 2015.

[10] Devarakonda, Srinivas, et al. "Real-time air quality monitoring through mobile sensing in metropolitan areas." Proceedings of the 2nd ACM SIGKDD International Workshop on Urban Computing. ACM, 2013.

[11] Sandeep Sagar K S, Asha H, Dr. Narendra Kumar G, "Performance Evaluation of DSDV and AODV Protocols for Green Corridor Management in Metropolitan City", FUTURE COMPUTING: The Ninth International Conference on Future Computational Technologies and Applications, 2017, Greece.

[12] Tarun Agarwal, Obstacle Avoidance Robotic Vehicle using Ultrasonic Sensor for Obstacle Detection, www.elprocus.com/obstacle-avoidance-robotic-vehicle, visited on October 29,2017.

[13] MQ-7 Carbon Monoxide Sensor Circuit Built with Arduino, http://www.learningaboutelectronics.com/Articles/MQ-7-carbon-monoxide-sensor-circuit-with-arduino.php, 2016, visited on November 18,2017.