International Journal of Engineering & Technology, 7 (2.7) (2018) 1045-1050

International Journal of Engineering & Technology

Website: www.sciencepubco.com/index.php/IJET

Research paper



IoT for monitoring carbon monoxide (CO) emissions using wireless sensor networks in smart cities

Vijaya Lakshmi Paruchuri [1] *, Dr. P. Rajesh [1]

[1] Department of Computer Science and Engineering, Koneru Lakshmaiah Education Foundation, Vaddeswaram, Guntur, Andhra Pradesh

**Corresponding author E-mail: parchuri.vijaya@gmail.com*

Abstract

A Smart city is characterized by the efficient use of information technology and industrial assets for financial improvement. Internet of Things (IoT) is an arrangement of embedded devices that communicates by using the internet and uniquely addressable with standard protocols. Application areas of Internet of things are smart cities, environmental protection, smart transportation, healthcare, agriculture and public security. Development of Smart cities leading to Pollution. Air Pollution is an environmental health concern for the public. Carbon Monoxide is a harmful gas to the human beings and also the leading cause of air pollution. So it is necessary to develop a mechanism for the detection of carbon monoxide molecules. This paper presents a survey on the methods of measuring the Carbon Monoxide emissions by using Wireless Sensor Networks. Availability of CO data from a monitoring program can be utilized for providing the awareness to the public about the air pollution.

Keywords: *Air Pollution; Wireless Sensor Networks; Environmental Monitoring; Internet of Things; Smart city*.

1. Introduction

In Internet of Things, smart objects are get connected with the computing technology. Internet will play an important role in the communication of physical things. Physical objects can be empowered through the embedded electronics into it, to make them smart and at the same time IoT gives the connection among these objects to give high quality of life to the people. Hardware, software components works cooperatively to build the IoT. This Technology is used in the development of Smart Cities.

A Smart city is characterized by the efficient use of information technology and industrial assets for financial improvement. Internet of Things (IoT) is an arrangement of embedded devices that communicates by using the internet and uniquely addressable with standard protocols. Application areas of Internet of things are smart cities, environmental protection, smart transportation, healthcare, agriculture and public security. An IoT application provides services to the industries, citizens and the administrative authorities in decision making. But the development of Smart cities leading to the major problem of Air pollution because of Industrialization [1].

Air Pollution is a serious issue which prompting to the health effects of the general population. Today most of the people live in the locality where air poison levels higher than the WHO indicated limits. Air contamination is the reason for worldwide environmental change and natural issues, for example, acid rain, ozone exhaustion and harm to crop. Thus there is a worldwide need to deal with this issue.

Air Pollution is checked by estimating the toxins like Carbon Monoxide (CO), Nitrogen Dioxide (NO2), and Carbon Dioxide (CO2) by utilizing precise and modest instruments at settled spots. Because of advances in sensor technology, computerized hardware, wireless communications have prompted the development of another Paradigm for air contamination monitoring. This aims to assemble high-determination spatiotemporal air contamination information by utilizing a sensor for observing ongoing groupings of various air poisons, which can be then used for a variety of air pollution management tasks [2].

The rate of progress in carbon monoxide focus in the earth isn't direct and is influenced by various factors. These days, industries are developing quickly. Industrial machines have enormously added to natural contamination with their carbon monoxide yield. Estimation of is normally just completed at one point in a wide area and it is done physically. This technique is unable to describe the CO concentration in real-time. The utilization of wireless sensor innovation deals with this issue. Estimation of CO by using wireless sensors is required to see the changes in CO fixation.

This work is organized in the following way:

1) Introduction
2) Challenges and Issues of Measuring the Carbon Monoxide Emissions
3) Motivation
4) IoT Applications in Smart Cities
5) IoT Based Sensor Data Collection of Carbon Monoxide emissions
6) Comparative Review of Carbon Monoxide Measuring Methods
7) Conclusion.

2. Challenges and issues of measuring the carbon monoxide emissions

Carbon Monoxide is a Colorless, poisonous gas. It is not detectable by individuals and can cause side effects, for example migraine and furthermore be driving the victim to death. CO has been recognized as dangerous air contamination by World Health

Copyright © 2018 Vijaya Lakshmi Paruchuri, Dr. P. Rajesh. This is an open access article distributed under the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

Organization (WHO). Environmental Protection Agency (EPA) furnishing rules concerning the levels of CO that must not be exceeded.

Carbon Monoxide goes into the body through the lungs and taken up by the blood by holding with hemoglobin found in red platelets. CO goes about as an aggressive inhibitor to oxygen as the two gases compete for binding on the same hemoglobin particle. The resultant structure following the connection of CO is called Carboxy Hemoglobin (COHb). The level of COHb causes various health effects like headache, drowsiness finally leading to the death.

Common Sources of Carbon Monoxide emissions are Gas Appliances, water heaters/heating devices, mobile gas containers, vehicular exhausts, coal, furnace, charcoal grills. In addition to these Fig.1 represents the major sources of Carbon Monoxide emission [3].

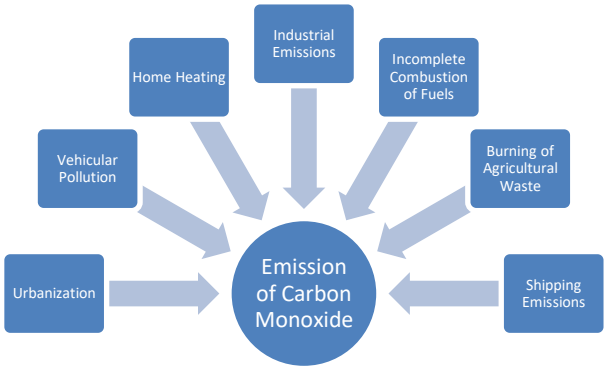


Fig. 1: Common Sources of Carbon Monoxide Emissions.

Air Pollution Control Board expected to execute the strategies to provide awareness among residents. In Recent days, Our National Capital Delhi faces the issue of Air contamination. Delhi is declared as one of the most contaminated urban areas in the world. Research on emissions of Carbon monoxide was doing however the issue remains same controlling the Air contamination helps improvement of environment and obviously the quality of life.

The problem of Carbon monoxide is still exists because of the many reasons. Common reasons and Preventive ures of Carbon Monoxide are mentioned in the following Fig. 2.

3. Motivation

In recent years, Government is planning to make every city as Smart city. Development may lead to some inconvenience. Example of this is the Air Pollution in Smart Cities. Delhi, our national capital of India is now recognizing as one of the most heavily polluted cities in the world. This pollution is because of Industrial development and motor vehicles. Environmental pollution makes breathing as a major problem thus reducing the life expectancy of the people.

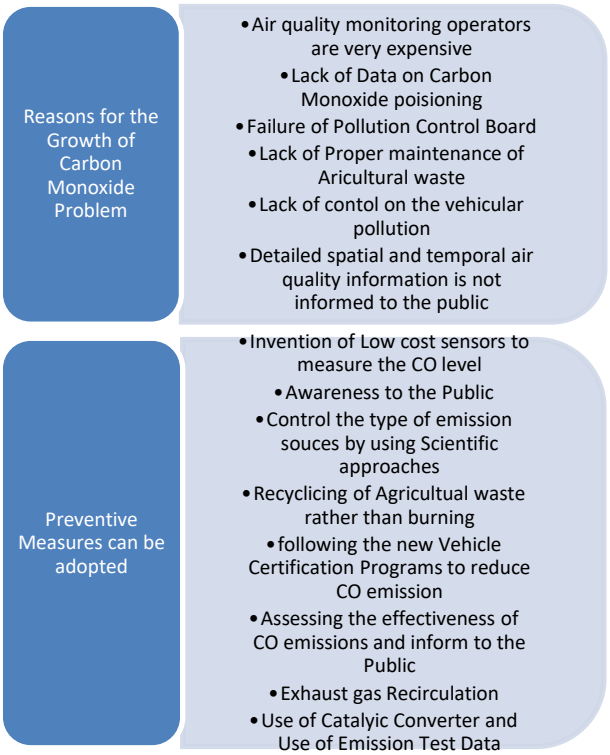


Fig. 2: Reasons for the Growth of Carbon Monoxide And its Preventive Measures.

Controlling the Air pollution helps in the improvement of natural environment and obviously the life quality. So the developing cities are creating mechanisms to monitor the environmental parameters and let their analysis be known to the citizens with the purpose of understanding the impact of environmental pollution.

Internet-of-Things for monitoring environmental variables in Smart cities is growing fast and its purpose is to offer the information at right time for decision making. This data can be used by the authorities in cities to generate early alerts on environmental pollution, opportunities to take the necessary measures to solve the pollution problems [4].

4. IoT applications in smart cities

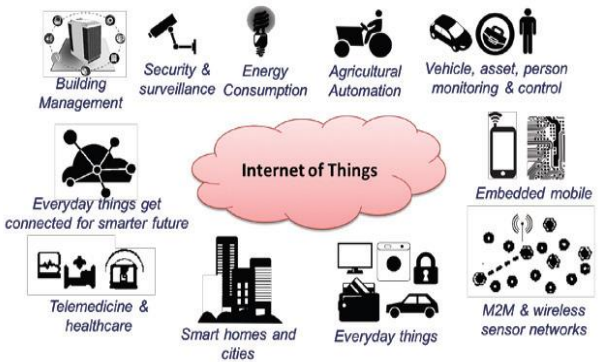


Fig. 3: IoT Application Domains.

Application areas of Internet of things are smart cities, environmental protection, healthcare, agriculture, smart transportation and public security, smart displays, vehicles, sensor monitoring etc. Fig. 3. shows the IoT application domains. IoT allows the development of applications, to take the information from these connected objects and provides services to the industries, citizens and the administrative authorities in decision making [5].

Today there exists in many cities a lot of problems related to the routinary process of management. These problems are generally related to the different ways the processes are conducted as for example the vehicular chaos, information supplied to the citizens

or the effectively on the peremptory changes of facts without previous notice to the citizens. Development and implementation of the smart cities is the solutions to these problem.The smart cities play the major role in the urban development. This will reduce many problems concerning the difficult problems of urbanizing as for example, traffic jams, environmental contamination, natural resources limitation.

A smart city is characterized by the appropriate and efficient use of information and the technology infrastructure for communications, human resources, social as well as industrial resources for the development.

Development of architecture on the internet of things (IoT), allows arrangement of sensors to collect information which is related to environmental variables and allowing the integration of any type of sensors associated with the measurements for a smart city environment. The collected data is to determine the different environments of a smart city. By using this information as a tool, decision making capabilities are increased, ranging from improvements in city design to the increase and improvements in the well being of the city's inhabitants. This article is the development of a multipurpose architecture based on the IoT for smart cities to measure the levels of Carbon Monoxide, with the capability to accept any type of sensors for decision making.

5. IoT based sensor data collection of carbon monoxide

Inter-connection among the objects plays a major role in IoT. Design issues of IoT are Interoperability, extensibility and scalability. In addition to these issues, physical characteristics of devices should be considered. Fig.4. represents the architecture of IoT based Sensor Data Collection of Carbon Monoxide.

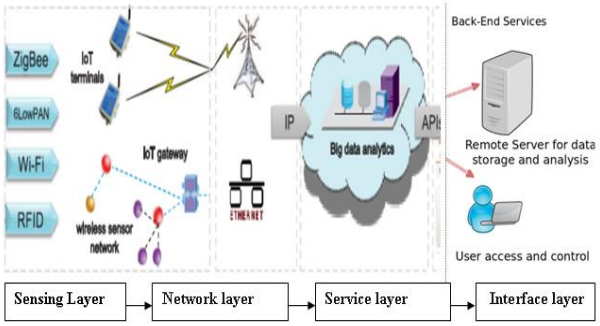


Fig. 4: Architecture of IoT based Sensor Data Collection of Carbon Monoxide.

This Architecture consists of four major layers [6].

First layer is Sensing Layer which is responsible for collecting the data related to the Carbon monoxide emissions. This can be done by employing wireless sensor network which is capable of measuring the CO levels.

Second Layer is Network Layer, after the collection of CO data; interface every smart object, so that can share the information.

Third Layer is the Service layer, it performs services like communication among the devices, storage and management of Carbon Monoxide data. Cloud computing technology used in this layer to store and process Big data.

Fourth Layer is Interface Layer. Administration and the interconnection of things become simple by using an interface. Interface Profile (IFP) is a model that permits cooperation with applications executing on the application layers.

5.1. Sensing layer (wireless sensor devices)

Smart systems are used to measure the environmental data. To control and track, each and every object must possess its own identity. Universal Unique IDentifier (UUID) is a method of allotting unique identity to the smart object. Cost, energy consumption, size, resource, deployment method, topology of the network, Protocols are perspectives to be considered in designing the sensing layer of an IoT [6].The techniques used in the sensing layer are the Wireless Sensor Networks, RFID, barcode and so on.

5.1.1. Wireless sensor networks

The WSN comprises of nodes, sensors communicates with each other through the nodes. These nodes are arranged in star topology where every node associates with other. Every node collects the data from the sensor and imparts it to other nodes. A sensor node comprises of a microcontroller, power source, transceiver, external memory and one or more sensors. WSN comprises of sensor node, a client, and an interconnected backbone [7]. Fig.5. Presents WSN Network system architecture, comprising of sensor nodes, which are used as a part of monitoring the environment, In WSN, the sensor nodes shares the data with each other and sends the processed information to the sink node. All the nodes send their data to the sink node, which is sent to clients with the help of the internet [7].

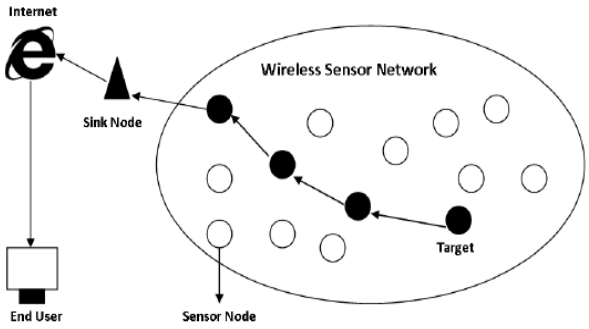


Fig. 5: Wireless Sensor Network (WSN) System Architecture.

Following table shows the Comparative Review of Carbon Monoxide Measuring Methods proposed by the different authors.

5.2. Network layer (data connectivity)

Purpose of network layer in the IoT architecture is to interface every smart object, so that can share the information. With the help of this layer, everything is constantly informed about their environment and data exchange from the sensing layer to the service layer. Carbon Monoxide data which is collected by the wireless sensors technology is placed in a connected environment. Technologies used here are 3G, Bluetooth, ZigBee, infrared, wifi and so on.

Table 1: Comparative Review of Carbon Monoxide Measuring Methods

S. No	Authors	Method Used for Measuring Carbon Monoxide	Type of Carbon Monoxide Sensor Used	Accuracy	Advantage	Disadvantage
1.	Suryono Suryono, Bayu Surarso et al.2017[8]	Proposed CO Measurement system using WSNs. The system node includes a CO sensor, a data acquisition system, and a communication system from remote terminal unit (RTU) to a Web server.	CO sensor of type SnO2 semiconductor.	average error of 7.73 ppm with Mean Absolute Percentage Error (MAPE) value of 2.81%.	Low Cost and Electrical conductivity of SnO2 sensor in clean air is low.	sensor heater, at some point, may not be able to warm up the sensors hence, sensors' Sensitivity decreases.
2.	Zhou, X., Aurell et al. 2017 [9]	Proposed The sensor system, termed Kolibri. The Kolibri is controlled by a microcontroller which can record and transfer data in real time through a radio module.	An electrochemical carbon monoxide (CO) sensor (EC4-500)	percentage error of 4.9%	The Kolibri system can be applied to open area scenarios such as fires, lagoons, flares, and landfills technical feasibility, low weight, and limited power consumption.	An additional amplifying circuit was incorporated to make the output from the electrochemical sensor compatible with the Kolibri data logging system.
3.	Philipp Schneider, Nuria Castell et al. 2017 [10]	Deployed a network of AQMesh platforms for monitoring air Quality. AQMesh units are battery driven stationary platforms which measure the components CO, NO, NO2, ozone and particle count.	CO is measured using infrared spectroscopy (EN14626)	root mean squared error of 14.3 μg m−3	measure the four gaseous components CO, NO, NO2, ozone and also measures air temperature, humidity and pressure.	when the observations from multiple sensors are subject to significant biases, the resulting maps will also be of poor quality.
4.	Konstantinos Tzortzakis,Konstantinos Papafotis et al. 2017 [11]	implementation of a wireless sensor network based on the LoRa protocol. Sensor nodes with embedded temperature, humidity, luminance, carbon monoxide, methane, alcohol and smoke detection sensors transmit the collected data to a base station (gateway) using LoRa. LoRa is a chirp spread spectrum (CSS) radio modulation LPWAN technology	Carbon Monoxide sensor (MQ7 - Winsen)	Range: 300ppm - 10000ppm and Accuracy is ±20ppm	The system is self powered using solar energy for battery charging to maintain Uninterrupted function.	The wireless communication protocol is based on a time slot scheme. The gateway's LoRa receiver is active in predefined Time slots during the day. Peripheral nodes schedule data transmission based on these time slots.
5.	Luca Dalla Valle et al. 2017 [12]	Portable multi-sensor Sensordrone. It is a pocket-sized device and it connects wirelessly to a smart phone	Gas sensors for oxidizing and reducing gases are metal oxide sensors (MOS)		new low cost's tools equipped with gas monitoring sensor	The Sensing properties depend on the response between the semiconductor metal oxide and oxidizing or diminishing gases in the air which prompt changes in Conductivity.
6.	Mahesh Jivani, Ronak Vithlani et al. 2017 [13]	IoT is used for consistent monitoring various environmental sensors by means of low cost open source embedded system	Carbon Monoxide MQ7 Sensor	MQ7 sensor can measure concentrations of 10 to 10,000 ppm and can function at temperatures from -10 to 50°C	sensing information broadcast through the projected unified network construction is very much reliable	sensor heater, at some point, may not be able to warm up the sensors optimally, hence, sensors' sensitivity decreases.
7.	Laurent Spinelle, Michel Gerboles et al. 2017 [14]	carbon monoxide sensors can achieve the Data Quality Objective (DQOs) of 25% of vulnerability	Two CO/NO2combined metal oxide sensors used. These sensors, TGS-5042, the MICS 4514, can recognize NO2and CO at the same time with two distinc-	TGS-5042 , 0–10000 _mol/mol MICS-4514 0–1000 _mol/mol	Reduce installation and main-tenance cost and allow larger scope in remote zones	Absence of selectivity, which makes them unreliable.

			tive signal output.			
8.	C. Borrego et al. 2016 [15]	Environnement CO11M Airpointer - Recordum	Infrared photometry EN 14626	0-100 mg m_3 0-86 ppm	The gathered real-time data combined with standard monitoring methods applied in new methodologies for air quality control.	Long-term drifts were not assessed.
9.	Bambang Sugiarto, Rika Sustika et al. 2016 [16]	Every sensor node will transmit the air quality information to the base station controller (BSC). This information comprises of climate condition,CO and CO2, temperature and humidity.	DR1048 board from Jennic as a sensor node	Accuracy 85.71% Precision 81,81% Sensitivity 60,00% Specificity 92.31%	Used for Purposes like in decision support system, report system, and others.	The computational process and the capacity of the program code are limited.
10.	Movva Pavani, P.Trinatha Rao et al. 2016 [17]	Air pollution information are gathered from the created test beds in the frame numbers and is available through middleware and a web interface. Air contamination checking with the help of wasp mote.	CO_2 sensor TGS4161 and O_2 sensor KE-25	Equation for CO2 sensor is P = A*Q + B, P is the calculated voltage Q is the CO2 concentration Coefficients A= 0.011992, B = -3.6973	simple and economical	There is an irrelevant variation in the Oxygen levels of 0.1 to 0.2 % with air contamination varieties.

5.3. Service layer (Cloud Management Platform)

In IoT, The service layer depends on the middleware technology that supports services, applications. The middleware guarantees the interoperability among the devices. The service layer performs services like communication among the devices, storage and management of data. Cloud computing technology used in this layer to store and process the Big data of Carbon Monoxide which is collected from the Sensors.

Cloud computing is turning into the reason for Big data needs. At the infrastructure as a Service (IaaS) level, Big data can utilize the storage capacities of cloud and in the meantime depend on calculation inside VMs 10. Likewise Hadoop introduced into Virtual machines is streamlined for big data processing. Hadoop is the open source system for handling the Big data with MapReduce approach [18].

5.3.1. Data storage and analytics

The utilization of Bigdata advancements for the smart city empowers information storage and processing to produce the data that can improve different smart city services. Big data helps in decision making to improve the smart city services. Big data processing technologies depends on the distributed data management, parallel processing, data repositories, distributed processing and interactive data visualization.

Big data store systems as of now utilizing are Hbase, MangDB, CouchDB, DynamoDB, Cassandra and Redis. The stored data are prepared relying upon the incoming queries utilizing MapReduce Framework or other processing engines used for big data. MapReduce gives an effective programming model to parallel and distributed processing of large data on clusters [19]. In stream processing information must be handled rapidly with the goal that organizations and people can respond to changes continuously in a smart city environment. Spark, Storm and S4 are the technologies can be useful on unstructured data in real time [19].

5.4. Interface layer (management portal)

Compatibility should be maintained to understand the communication among the heterogeneous things. Administration and the interconnection of things become simple by using an interface. Interface Profile (IFP) is a set of service models that permits cooperation with applications executing on the application layers. Users can access the data related to CO emissions from this layer.

6. Comparative review of carbon monoxide measuring methods

Table 1 Contains the Comparative Review of Carbon Monoxide Measuring Methods.

7. Conclusion

The IoT intends to change over our regular world into smart one by empowering our lifestyle. Design, Protection, Security, openness, Bigdata, Scalability and versatility are the essential challenges that must be solved. It assists the IoT's application designers with building a solid and dependable IoT framework. It makes them aware of normal issues that must be tended to, so they can take counter measures when developing the IoT applications.

This paper presented a review on monitoring Carbon Monoxide emissions using Wireless Sensor Networks. Air quality data collected as a result of monitoring is shared with the public for creating the awareness about the health effects of Carbon Monoxide and also the government authorities for taking necessary steps for the prevention. In future there is a need for developing the low cost and accurate sensor devices and monitoring equipment which can help the people by providing the information in advance [20].

References

[1] Tarikul Islam, Member, IEEE, Subhas Chandra Mukhopadhyay, Fellow, IEEE, and Nagender Kumar Suryadevara, Senior Member, IEEE, Smart Sensors and Internet of Things: A Postgraduate Paper, IEEE SENSORS JOURNAL, VOL. 17, NO. 3, FEBRUARY 1, 2017.

[2] Fadi Kizel , Yael Etzion , Rakefet Shafran-Nathan , Ilan Levy , Barak Fishbain , Alena Bartonova , David M. Broday , Node-to-node field calibration of wireless distributed air pollution sensor network, 2017 Elsevier, Pg 1-10.

[3] Aakash C. Rai , Prashant Kumar, Francesco Pilla, Andreas N. Skouloudis , Silvana Di Sabatino ,Carlo Ratti , Ansar Yasar , David Rickerby , End-user perspective of low-costsensors for outdoor air pollution monitoring, A.C. Rai et al. / Science of the Total Environment 607–608 (2017) 691–705.

[4] Jorge E. Gómeza, Fabricio R. Marcillob, Freddy L. Trianab, Victor T. Gallob Byron W.Oviedob, Velssy L. Hernándeza ,JorgeE . G ómezet "IoT FOR ENVIRONMENTAL VARIABLES IN URBAN AREAS" al./ ProcediaC ompute rS cience1 09C(201 7) 67– 74 Góme zetal / Pr ocediaComputerScience0 0(2015) 000– 000.

[5] Iman Khajenasiria, Abouzar Estebsarib, Marian Verhelsta, Georges Gielena Iman Khajenasiri; A review on Internet of Things solutions for intelligent energy control in buildings for smart city applications et al. /Energy Procedia 111(2017)770 – 779.

[6] Sarra Hammoudi, Zibouda Aliouat, Saad Harous; Challenges and research directions for Internet of Things,Telecommun Syst (2018) 67:367–385.

[7] Ahmad Ali, Yu Ming, Sagnik Chakraborty and Saima Iram ; A Comprehensive Survey on Real-Time Applications of WSN;Future Internet 2017, 9, 77 doi:10.3390/fi9040077.

[8] Suryono Suryono, Bayu Surarso, Ragil Saputra. Ali Bardadi, A Web-Based Wireless Sensor System to Measure Carbon Monoxide Concentration, Proc. EECSI 2017, Yogyakarta, Indonesia, 19-21 September 2017.

[9] Xiaochi Zhou,Johanna Aurell, William Mitchell, Dennis Tabor, Brian Gullettd, A small, lightweight multipollutant sensor system for 1 ground-mobile and aerial emission sampling from open area sources, Atmospheric Environment, 10.1016/j.atmosenv.2017.01.029.

[10] Philipp Schneider, Nuria Castell, Matthias Vogt, Franck R. Dauge, William A. Lahoz, Alena Bartonova, Mapping urban air quality in near real-time using observations from lowcost sensors and model information, Environment International 106 (2017) 234–247.

[11] Konstantinos Tzortzakis∗, Konstantinos Papafotis and Paul P. Sotiriadis, Wireless Self Powered Environmental Monitoring System for Smart Cities based on LoRa, 978-1-5386-2287-2/17/$31.00@ 2017 IEEE.

[12] Luca Dalla Valle, Giorgia Passamani, Elena Cristina Rada, Vincenzo Torretta, Unconventional Reducing Gases Monitoring in Everyday Places, Energy Procedia 119 ,(2017) 3–9.

[13] Ronak Vithlani2, Siddharth Fultariya2, Mahesh Jivani1, Haresh Pandya1, An open source real time IoT based environmental sensor monitoring system, Kalpa PublicationsinComputing, Volume2,2017,Pages145-150.

[14] Laurent Spinelle, Michel Gerboles, Maria Gabriella Villani, Manuel Aleixandrec,Fausto Bonavitacola,Field calibration of a cluster of low-cost commercially availablesensors for air quality monitoring. Part B: NO, CO and CO2, Sensors and Actuators B 238 (2017) 706–715.

[15] C. Borrego, A.M. Costa, J. Ginja, M. Amorim, M. Coutinho, K. Karatzas, Th. Sioumis, Assessment of Air Quality Microsensors Versus Reference Methods: 1 the EuNetAir Joint Exercise, Atmospheric Environment, 10.1016/j.atmosenv.2016.09.050.

[16] Bambang Sugiarto, Rika Sustika, Data Classification for Air Quality on Wireless Sensor Network Monitoring System Using Decision Tree Algorithm, 978-1-5090-4357-6/16/$31.00 ©2016 IEEE.

[17] Movva Pavani, P.Trinatha Rao, Real Time Pollution Monitoring Using Wireless Sensor Networks, 978-1-5090-0996-1/16/$31.00 ©2016 IEEE.

[18] M. Fazio, A. Celesti, A. Puliafito, M. Villari M. Fazio; Big Data Storage in the Cloud for Smart Environment Monitoring et al. / Procedia Computer Science 52 (2015) 500 – 506.

[19] Ibrahim Abaker Targio Hashem, Victor Chang , Nor Badrul Anuar, Kayode Adewole, Ibrar Yaqoob, Abdullah Gani, Ejaz Ahmed, Haruna Chiroma;The Role of Big Data in Smart City;Article in International Journal of Information Management,May 2016.

[20] Aminuddin Debataraja, Ahmad Rifqi Muchtar, Ni Luh Wulan Septiani, Brian Yuliarto, Nugraha, and Bambang Sunendar ;High Performance Carbon Monoxide Sensor Based on Nano Composite of SnO2-Graphene;EEE SENSORS JOURNAL, VOL. 17, NO. 24, DECEMBER 15, 2017.