Technoarete Transactions on Internet of Things and Cloud Computing Research
Vol-2, Issue-3, September 2022
e-ISSN: 2583 - 0805

IoT Based Air Quality Monitoring System

G. Shashank[1], V. Sriram Lohit[2*], G. Venkata Sai Vishal[3]

[1,2,3] Department of Electronics and Communication Engineering, Chaitanya Bharathi Institute of Technology, India
Author Email: [2] sriramlohitv@gmail.com

Abstract

"IoT Based Air Pollution Monitoring System" supports showing the quality of air in PPM over the LCD along with that on the web sheet therefore, as this can simply be scrutinized. In order to show the impact of "IoT based Air Quality Monitoring System", flowcharts, graphs, digraphs and tables have been shown in an effective manner. According to the Statista, it has been estimated that "air quality monitoring IoT" services along with products would be a significant economic value of 50 up to 60 billion US dollars by the year of 2025. In the present times the condition of air is not that good due to the increasing pollution rate in the past several years. In order to conduct this research work in an effective manner, a secondary data collection method has been taken and all the secondary data resources have been taken to conduct the research in a suitable manner.

"IoT based Air Quality Monitoring system" has been suitably designed to quantity the mutual "air quality index" and it also helps in standardizing the results with "India's Air Pollutant Index" to suitably indicate the strictness of air superiority. The most harmful air pollutant gasses are NOx, LPG, CO2, NH3, Benzene, alcohol and benzene. In addition, with the help of this system, temperature along with humidity both can effectively be monitored. LPG gas has been suitably detected to use MQ135 and MQ6 sensors and this has been used for monitoring the air's quality as it helps in detecting all these harmful elements. In this research work, it has been shown that focusing on "Triple Bottom Line " theory can be effective as this theory helps in showing the ways through which environmental sustainability can be maintained easily.

Keywords

Air Quality Monitoring IoT, India's Air Pollutant Index, IoT based Air Quality Monitoring System.

INTRODUCTION

"IOT based quality monitoring system" utilizes different sensors to monitor the water quality through determining turbidity, pH, temperature and conductivity. The beginning points of this, "*air quality monitoring system*", is to first analyze if any area is having air pollution related issues. On the other hand, it can also be stated that, this monitoring of air quality through IoT can support in assessing the pollution level in association with the "*ambient air quality standards*". In this research article, an in-depth illustration of this "*IoT based air quality system*" has been shown with the support of diagrams, graphs, tables and algorithm focused flowcharts.

LITERATURE REVIEW

Importance of "IoT based Air Quality Monitoring System"

Air pollution can be recognized as the biggest issue of each and every nation, irrespective of developing or developed. In addition, health issues in the urban sites of developing cities where industrialization and increasing estimation of conveyances leads towards releasing of several gaseous pollutants. As per a survey, it can be stated that due to the air pollution cases "50,000 up to 100,000 premature deaths" every year happen across the overall mainland of U.S alone [1]. "*IoT based Air Pollution Monitoring System*" helps in monitoring the quality of air through a web server utilizing the Cyberspace and would trigger an awareness when the excellence of air decreases to a convinced level. This happens when an adequate estimation of harmful gasses is there in the air such as alcohol, smoke, benzene, CO2, NH3, NOx and LPG.

It can be stated that with the support of this system Humidity and Temperature both can easily be monitored and detected and the amount of these harmful gasses can also be monitored. LPG gas has been perceived using "*MQ6 sensor"* along with "*MQ135 sensor".* It is utilized for observing quality of air as it distinguishes all these types of harmful gasses and might also measure their estimation in the air carefully [2]. According to the below table, the motionless pattern of "Air Quality Monitoring System" consists of these "Analytical Instruments" and that is expensive. A "lower cost air quality monitoring system" has been effectively established, that only concentrated on "*dust pollutants monitoring*" through utilizing "*Sharp GP2Y1010AU0F sensor*".

Table 1: Comparison among pollutants sensors and analytical instruments

Characteristics	Analytical instruments	Sensors for checking quality of air
Cost	***Very high***	***Fair***
Resolution	***Excellent***	***Reliable***
Size	***Bulky***	***Compact***
Mobility	***Difficult***	***Easy***

Technoarete Transactions on Internet of Things and Cloud Computing Research
Vol-2, Issue-3, September 2022
e-ISSN: 2583 - 0805

WORKING BLOCK DIAGRAM

Projected **"*Air Pollution Monitoring System*"** is dependent on the ***block diagram*** and this block diagram has been reflected in the figure 1. In addition, the data related to air can be recognized through "*MQ135 gas sensor*" along with "*MQ6 LPG gas sensor*". On the other hand, this MQ135 can support in sensing NOx, NH3, Benzene, alcohol, CO2 and smoke and it can be highlighted that it is *"dynamic gas sensored"*for the "Air pollution Monitoring System" [3]. During the time it is interlinked with Arduino then this would sense several other gasses along with that this would provide the level of pollution in *"parts per million"* (PPM). As per the model all the four sensors are working as input data, and it transmits data to know specifically which gas it is, and what is the humidity and temperature. It is also needed to illustrate that Buzzer and LCD both are recognized as the production devices. In addition, LCD highlights the information of all the gasses in "*Parts Per Million*".

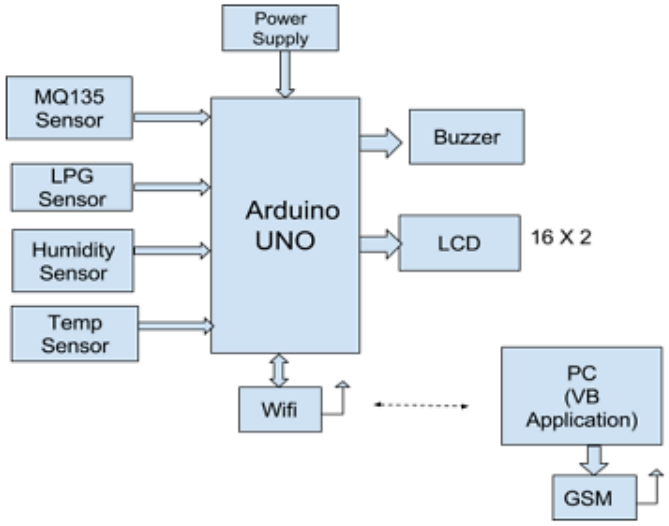

Figure 1: Block diagram [3]

In terms of showing the "Air Quality Level Indicator" the below figure has been shown and this figure illustrates the "Comprehensive Indoor Air Quality Indicator (CIAQI) computation flow" during the time EMA has been applied. In addition, *EMA* has been performed for specific pollutants along with that the updated values through EMA are utilized for this IAQI estimation [4]. In addition, with the support of this algorithm flowchart any person without having any environmental knowledge might simply identify the present "indoor air-quality status". In addition, it can be stated that focusing on ***"Triple Bottom Line"*** theory can be beneficial as this theory can be recognized as an effective concept that mainly posits that everyone needs to commit to measure the environment and social impact [5]. In addition, this theory can help in maintaining environmental sustainability and if environmental sustainability is maintained effectively then air pollution can also be mitigated.

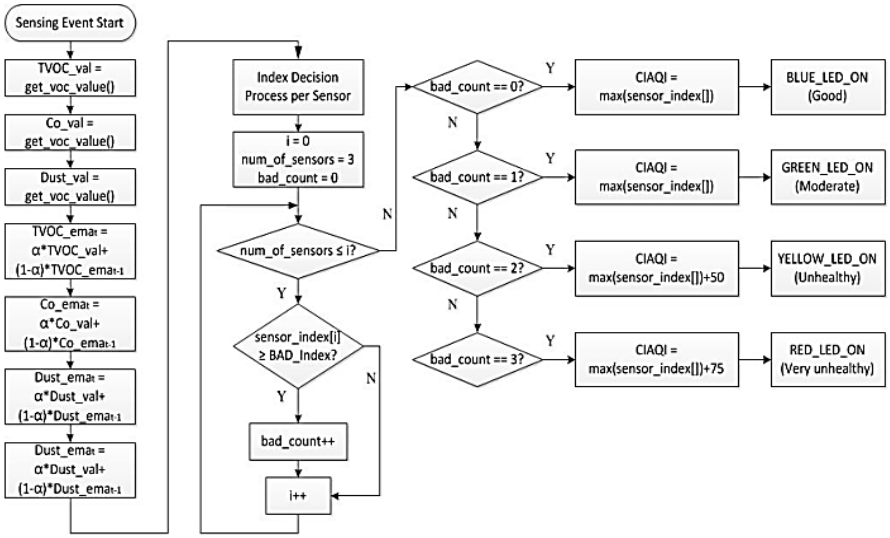

Figure 2: Flowchart of CIAQL [4]

Technoarete Transactions on Internet of Things and Cloud Computing Research
Vol-2, Issue-3, September 2022
e-ISSN: 2583 - 0805

MATERIALS AND METHODS

In this study it can be highlighted that, the secondary data collection method has been utilized in an effective manner and this data collection method has been utilized as it is cost effective, time saving and a simpler process to use. In order to proceed with the secondary data collection method, secondary data sources have been gathered from scholarly articles, journals, newspaper articles, and books. All these resources have been gathered with the year of 2017 to 2022 and these resources are authentic and reliable [6]. The research strategy is that all the secondary data resources have been gathered using the secondary qualitative way. In this section it can also be illustrated that interpretivism research philosophy has been used as this research philosophy supports in illustrating that "IoT based Air quality monitoring system" is helping to investigate the pollution rate in the air.

This system has been designed to effectively measure the basic "air quality index" along with that it standardized the outcomes with "India's Air Pollutant Index" to effectively designate the air quality's severity. "The air quality monitoring system" is compressed with four instruments that have been combined within it and each individual has its own operational aspects to effectively quantity temperature, CO pollutant, PM_{10}, moisture and PM_{25}[7]. On the other hand, a proper construction of procedure flow has been suitably calculated along with that followed amidst the time of implementing this system. In addition, this procedure flow has been planned effectively to assure the research covering the entire work's objective. It can also be illustrated that an in depth "block system diagram of API monitoring" has been effectively illustrated in the below diagram.

The modules have been utilized in this specific system chosen depending on its functionality in terms of carrying out the work required for this specific system. In addition, *"Microcontroller Arduino Uno Rev, 3 Atmega328P"* can be recognized as adequate towards controlling this system [8]. It can also be highlighted that GSM Modem of SIM900 series utilized along with that with this dual network band, it might be able to carry out its effective functionality to effectively communicate with the telephones while "***LCD of 16x2 display***" utilized for close output imagining.

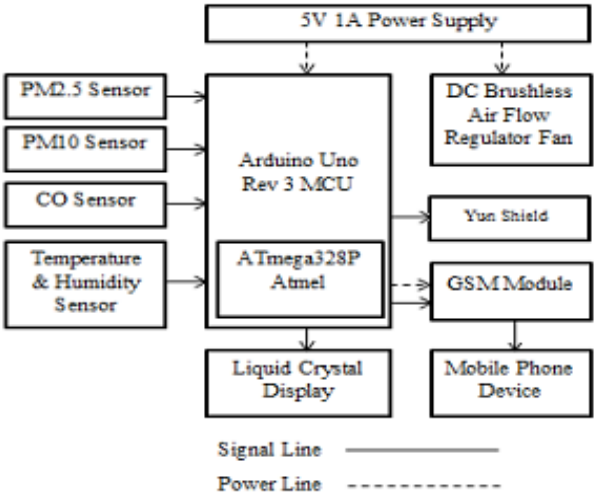

Figure 3: "Detailed system block diagram of the API monitoring" [7]

From the table 2, it has been shown that the sensors that have been combined in this arrangement are chosen depending on its competence of measuring that is intelligent to effectively perceive the higher pollutants depending on the "India's API scale" [9]. "***The higher the concentrations"*** detection range, the more costly the sensor is. Therefore, better assortment of the device in this work is to ensure that this specific sensor can have the ability to cover this API scale including that still it is reasonable in price range. It is also needed to portray that the ***"DHT22 sensor"*** has the abilities to effectively detect both humidity and temperature in the air.

Table 2: "Sensor's detection range" and "API pollutants concentration range"

Sensors	Pollutant's patterns	Range of detection	"API Pollutant Concentration Range"
"Figaro TGS 2600"	***"Carbon Monoxide"***	***"1-100 PPM"***	***0-57.5 PPM***
SHARP GP2Y1010AU0F	***PM 2.5***	***0-500 µg/m^3***	***0-500 µg/m^3***
SHAPER DN7C3CA006	***PM10***	***25-500 µg/m^3***	***0-600 µg/m^3***
DHT22	***Humidity & Temperature***	***"Humidity: 0-100% Temperature: -40–80℃"***	—

Among several other sensors that are there, the TGS 2600 (CO sensor), can be recognized as the only sensor that requires calibration for reliable and consistent results. R_0 can be recognized as the constant that requires to be considered through calibration procedure [10]. Moreover, 69.8 PPM of CO has been produced during the time 24 cigarettes have been smoked along with that has been contained for three hours without having any losses. In addition, by knowing this CO concentration, this R_0 value has generated by equation (5) along with (1) that is 28336.27Ω.

In terms of assuring the R_0 value produced is acceptable, an estimation of cigarettes smoked through sequence from 4, 16, 8, 24 have been shown. In addition, for individual sessions, this CO concentration has been measured after three hours of cigarette smoking [11]. This measurement results and reference data comparison has been shown in this below graph. In addition, the error has been estimated to scrutinize the unconventionality of measurement consequences with this reference data.

Technoarete Transactions on Internet of Things and Cloud Computing Research
Vol-2, Issue-3, September 2022
e-ISSN: 2583 - 0805

Table 3: Percentage error within reference data measured data

Estimation of Cigarettes	CO PPM's Reference	Estimated CO PPM	Percentage Error %
4	*12.21*	*13.06*	*6.96*
8	*25.65*	*24.90*	*2.92*
16	*47.63*	*46.10*	*3.21*
24	*69.80*	*67.73*	*2.97*

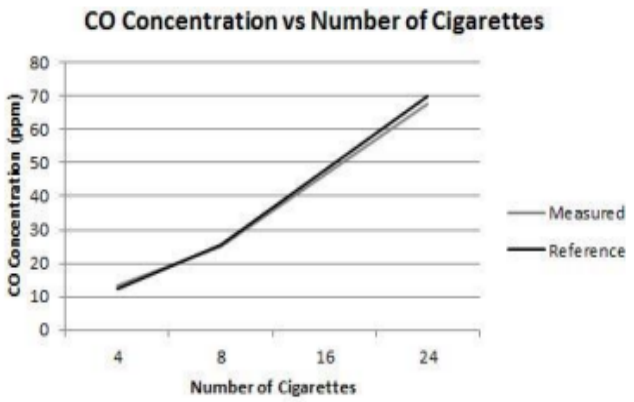

Figure 4: Estimation of cigarettes and CO concentration [11]

On the other hand, it can be stated that in the present situation the usage of "IoT based air quality monitoring system" has increased over the past years. The main reason behind that is, the estimation of harmful pollutants has been increased in the air. As per Statista, it has been assessed that the "air quality monitoring IoT" services as well as products would have an effective monetary value of 50 to 60 billion US dollars by the year of 2025 [12]. Moreover, this aforementioned range might be forecasted to expand to 60 up to 70 billion US dollars by the year of 2030.

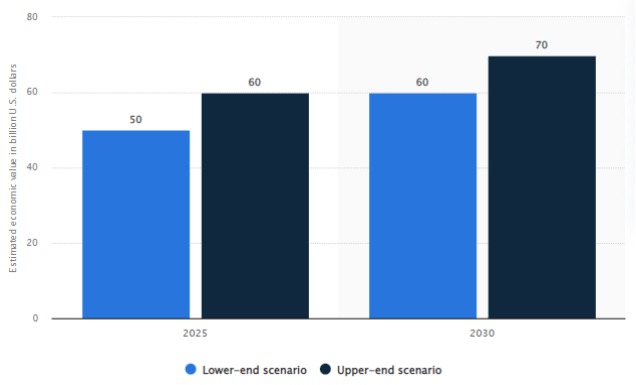

Figure 5: Predictable economic value of "IoT air quality monitoring system" [12]

RESULTS AND DISCUSSION

In recent times, the air condition is too polluted and in the present years, chemicals from all the factories, car emissions, dust and smoke are everywhere. It can be stated that this is the major reason behind these air pollution cases. On the other hand, the impact of air pollution is not good for public health and mainly several diseases can happen from this such as Asthma. In addition, "IoT based Air Pollution Monitoring System" is utilized for keeping the track of the quality of air over the web server utilizing the Internet. The combined device has been verified to effectively quantity the surrounding quality of air with the actual timing effective monitoring [13].

The below figure is showing an effective example of one day of "CO concentration monitoring" and the entire outcome reflects the decrease from 0100 hour until the 0600 hour along with that beginning to enhance pending the crowning hour. This tendency has been alleged due to this "peak working hours" and this ultimate hours for this CO attentiveness measurement is higher at "***1000 hour".*** On the other hand, the outcome from 1100 towards 1500 hour reflects a major decrease [14]. One of the most effective reasons is that CO specifically in the air is diminished as the activities of human performance efficiency are also lessening.

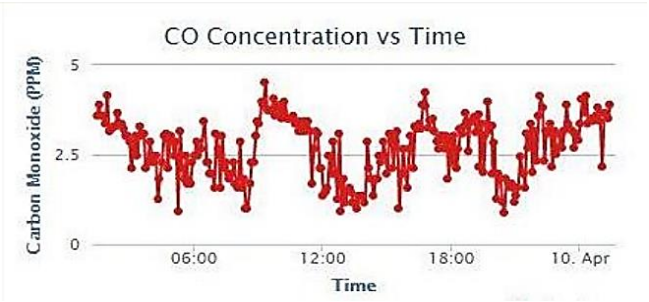

Figure 6: Time versus CO Concentration [14]

In the below flowchart, it has been shown that first it is necessary to measure the CO Concentration, then sub-API of this CO needs to be calculated. After this calculation, it is necessary to measure O_3 Concentration and then sub-API of this O_3 as these calculations can support in getting a better understanding about the impact of harmful gasses on the air. Side by side in this flowchart it has been shown that, it is also necessary to measure PM_{10} Concentration and then the sub-API of this PM_{10} [15]. In addition, effective calculation processes have been highlighted through the flowchart in an effective manner. After these calculations it has been highlighted that proper classification of API has been done as per the "color coded API Indicator". On the other hand, it has been shown that these API values would be stored effectively in the SD card and then this procedure would end.

Technoarete Transactions on Internet of Things and Cloud Computing Research
Vol-2, Issue-3, September 2022
e-ISSN: 2583 - 0805

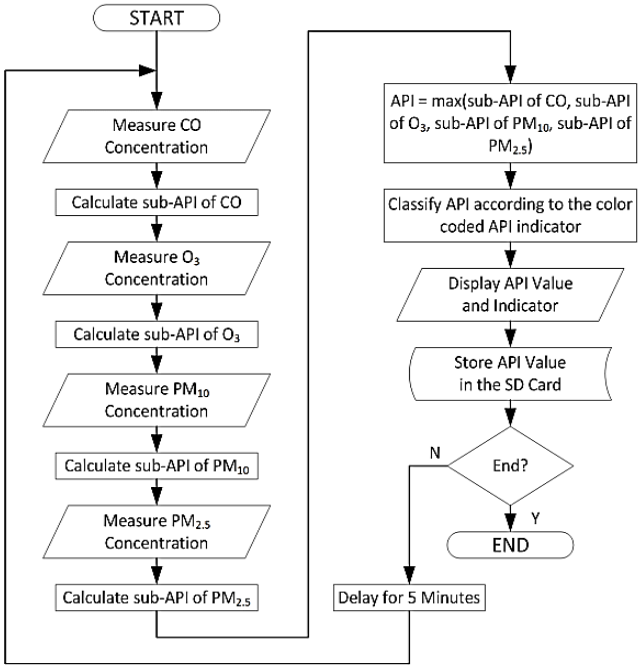

Figure 7: Flowchart on "IoT based Air Quality System" [15]

The below figure is showing that the single day analyzing day monitoring outcome has been obtained from secondary resources for temperature monitoring. Mainly, from the 0100 hour, a decreasing rate has been observed until the 0800 hour. On the other hand, this temperature begins to enhance from 0900 hour till its highest peak time where the higher degree of temperature has been recorded on a regular basis is 1600 hour [16]. In addition, much higher temperature has been logged at 1600 hour of direct daylight to the "API monitoring device" occurs at that period.

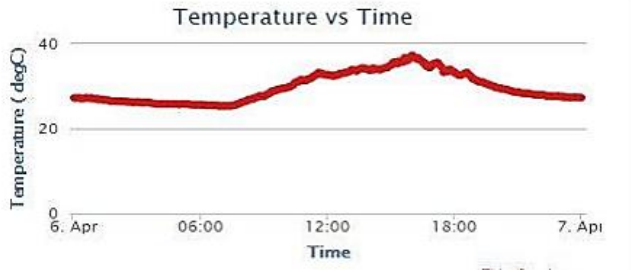

Figure 8: Time versus temperature [16]

Apart from that, in the below figure, five week's effective temperature monitoring has been monitored suitably. In addition, depending on the outcome, a much higher peak hour for this temperature monitoring can be considered at 1600 hour [17]. In addition, the outcomes plotted is having the similar trend as the one day's temperature monitoring.

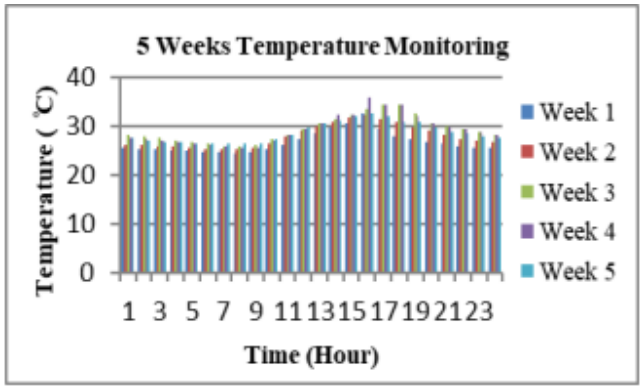

Figure 9: Temperature monitoring of five weeks [17]

DISCUSSION

As per the result section it can be highlighted that, in the present time air pollution rate has become higher than the past several years. however, in the requirement of lowering the rate of air pollution, the usage of "IoT based Air Quality Monitoring System" has been increased compared to the past years. An effective flowchart of the entire process to calculate the harmful gasses estimation has been shown in an effective manner [18]. In addition, in this flowchart it has been highlighted that first it is necessary to measure the CO Concentration and also need to calculate the sub-API of the CO. Temperature monitoring and temperature versus time have also been monitored and from this analysis it can be stated that temperature monitoring and time versus temperature helps in analyzing if any harmful gasses are there in the air or not. On the other hand, "CO concentration monitoring" is also supported to analyze if the air is containing any other harmful air pollutant or not [19]. Therefore, in order to analyze the harmful air pollutant in the air proper usage of "IoT based Air Monitoring System" can be beneficial.

CONCLUSION

IoT helps in enabling business firms to automate procedures and reduce labor costs. The starting point of this "air quality monitoring system" is that it helps in analyzing if any surrounding contains any air pollution related issues or not. Air pollution can be highlighted as the major issue of every nation, irrespective of developed and developing nations. In the requirement of highlighting the "IoT based Air Quality Monitoring System" tables, diagrams, graphs, flowcharts have been shown in an effective manner. "IoT Based Air Pollution Monitoring System" supports showing the quality of air in ***"PPM on the LCD"*** along with that on the web page therefore, a huge volume of benefits can be obtained in terms of monitoring the entire process.

REFERENCES

[1] Munera, D., Aguirre, J. and Gomez, N.G., 2021. IoT-based air quality monitoring systems for smart cities: A systematic mapping study. *International Journal of Electrical and Computer Engineering*, *11*(4), p.3470.

e-ISSN: 2583 - 0805

[2] Shah, H.N., Khan, Z., Merchant, A.A., Moghal, M., Shaikh, A. and Rane, P., 2018. IOT based air pollution monitoring system. *International Journal of Scientific & Engineering Research*, *9*(2), pp.62-66.

[3] Okokpujie, K., Noma-Osaghae, E., Modupe, O., John, S. and Oluwatosin, O., 2018. A smart air pollution monitoring system. *International Journal of Civil Engineering and Technology (IJCIET)*, *9*(9), pp.799-809.

[4] Al Tahtawi, A.R., Andika, E., Yusuf, M. and Harjanto, W.N., 2019. Design of quadrotor UAV and internet-of-things based air pollution monitoring systems. *IJITEE (International Journal of Information Technology and Electrical Engineering)*, *3*(4), pp.120-127.

[5] Saini, J., Dutta, M. and Marques, G., 2020. A comprehensive review on indoor air quality monitoring systems for enhanced public health. *Sustainable environment research*, *30*(1), pp.1-12.

[6] Benammar, M., Abdaoui, A., Ahmad, S.H., Touati, F. and Kadri, A., 2018. A modular IoT platform for real-time indoor air quality monitoring. *Sensors*, *18*(2), p.581.

[7] Taştan, M. and Gökozan, H., 2019. Real-time monitoring of indoor air quality with internet of things-based E-nose. *Applied Sciences*, *9*(16), p.3435.

[8] Sai, K.B.K., Subbareddy, S.R. and Luhach, A.K., 2019. IOT based air quality monitoring system using MQ135 and MQ7 with machine learning analysis. *Scalable Computing: Practice and Experience*, *20*(4), pp.599-606.

[9] Barot, V., Kapadia, V. and Pandya, S., 2020. QoS enabled IoT based low cost air quality monitoring system with power consumption optimization. *Cybernetics and Information Technologies*, *20*(2), pp.122-140.

[10] Sai, K.B.K., Mukherjee, S. and Sultana, H.P., 2019. Low Cost IoT based air quality monitoring setup using arduino and MQ series sensors with dataset analysis. *Procedia Computer Science*, *165*, pp.322-327.

[11] Kang, J. and Hwang, K.I., 2016. A comprehensive real-time indoor air-quality level indicator. *Sustainability*, *8*(9), p.881.

[12] Vailshery, S.L, 2022. *Estimated economic value from IoT in air quality monitoring worldwide in 2025 and 2030(in billion U.S. dollars)*. [Online]. Available at:https://www.statista.com/statistics/1318795/economic-value-from-iot-air-quality-monitoring/ [Accessed on: 10 September, 2022]

[13] Hawari, H.F., Zainal, A.A. and Ahmad, M.R., 2019. Development of real time internet of things (IoT) based air quality monitoring system. *Indonesian Journal of Electrical Engineering and Computer Science (IJEECS)*, *13*(3), pp.1039-1047.

[14] Ng, W.J. and Dahari, Z., 2020. Enhancement of real-time IoT-based air quality monitoring system. *International Journal of Power Electronics and Drive Systems*, *11*(1), p.390.

[15] Saini, J., Dutta, M. and Marques, G., 2020. Indoor air quality monitoring systems based on internet of things: A systematic review. *International journal of environmental research and public health*, *17*(14), p.4942.

[16] Purkayastha, K.D., Mishra, R.K., Shil, A. and Pradhan, S.N., 2021. IoT based design of air quality monitoring system web server for android platform. *Wireless Personal Communications*, *118*(4), pp.2921-2940.

[17] Kim, U., Kim, Y.C. and Kwak, S., 2016. Iot based indoor air quality monitoring system. *The Journal of the Korea Contents Association*, *16*(2), pp.143-151.

[18] Kalia, P. and Ansari, M.A., 2020. IOT based air quality and particulate matter concentration monitoring system. *Materials Today: Proceedings*, *32*, pp.468-475.

[19] Zhu, Y.D., Li, X., Fan, L., Li, L., Wang, J., Yang, W.J., Wang, L., Yao, X.Y. and Wang, X.L., 2021. Indoor air quality in the primary school of China—results from CIEHS 2018 study. *Environmental Pollution*, *291*, p.118094.