International Journal of Advances in
Soft Computing and Intelligent Systems (IJASCIS)
2022, Vol 01, No 01, 42-52

Science Transactions © 2022

Original Paper

ROLE OF TECHNOLOGY IN AIR QUALITY MONITORING SYSTEM: CASE OF RAJKOT CITY

Aniruddh Vaghela[1] and Dr. Gayatri Doctor[2]

[1]Faculty of Management, CEPT University, Ahmedabad, India
aniruddhvaghela9497@gmail.com
[2]Associate Professor, Faculty of Management, CEPT University, Ahmedabad, India
gayatri.doctor@cept.ac.in

ABSTRACT

Rapid urbanization and uncontrolled pollution has created a serious problem of air quality degradation. Indian cities perform poorly in terms of air quality standards, with high PM 2.5 levels which has many associated health impact. This shows the importance of having ambient air quality monitoring solutions that inculcate multi-stakeholder partnerships to reduce air pollution. It is very important to reduce the pollution level below the threshold level at which it poses no risk to human health. To monitor real time air quality level across the city, it requires a continuous air quality monitor networks to generate real time data related to air quality level in different part of the city. In this study, Role of technology to monitor air quality has been explored for Rajkot city.

KEYWORDS

Air quality monitoring, Technology, Smart cities

1. INTRODUCTION

1.1. Air quality monitoring

Rapid urbanization and uncontrolled pollution has created a serious problem of air quality degradation. Indian cities performs poorly in terms of air quality standards, with high PM 2.5 levels which has many associated health impact. Despite the effects, the response towards air pollution from citizens and government has been limited [1]. As mentioned by the World Health Organization (WHO), level of air quality is getting worse day by day in most low and middle-income cities. Contributing factors include industrialization, landfills, increased private vehicle, power plant, incineration and increased power demand and residential cooking through low cost chullha [2]. This shows the importance of having ambient air quality monitoring solutions that inculcates multi-stakeholder partnerships to reduce air pollution. It is very important to reduce the pollution level below the threshold level at which it poses no risk to human health [3]. To observe air quality level in real time across the city, it requires an air pollution data being generated continuously from monitoring network. Many times it is observed that pollution severity differs in different localities of same city. Hence, the air pollution concentration in a specific region depends on various conditions and local emission [4].

Advanced technologies with AI, ICT and IoT in new sensor based air quality monitoring system provides air pollution severity details on various pollutants with analysis. For monitoring air quality at city level, cost effective sensors deployed across city generates data, this data is transferred through GPRS, WIfi to centralized cloud platform and it creates real time visualization of air quality level across city.

1.2. Smart city

Smart Cities Mission, India was launched to promote cities that provide a clean and sustainable environment, quality lifestyle for citizens and core infrastructure. The mission focuses on enhancing economic growth and quality life through comprehensive progress on physical, economic, social and institutional pillars. The smart cities mission provides a unique opportunity to cities to adapt advanced air quality monitoring technologies. Cities are encouraged to implement affordable technologies by through low-cost air-quality sensors and connecting it to the Integrated Command and Control Centres as shown in figure 1 [5]. This monitoring system will provide further data on localized areas and hot spots which would help generate real-time air quality scenario for cities to take corrective action as well as necessary improvements. Fig.1 shows air quality data for various cities. Air pollution data will not only help the local government in making policies but inspire citizens to make informed decisions that can enhance the quality of their lives [6].

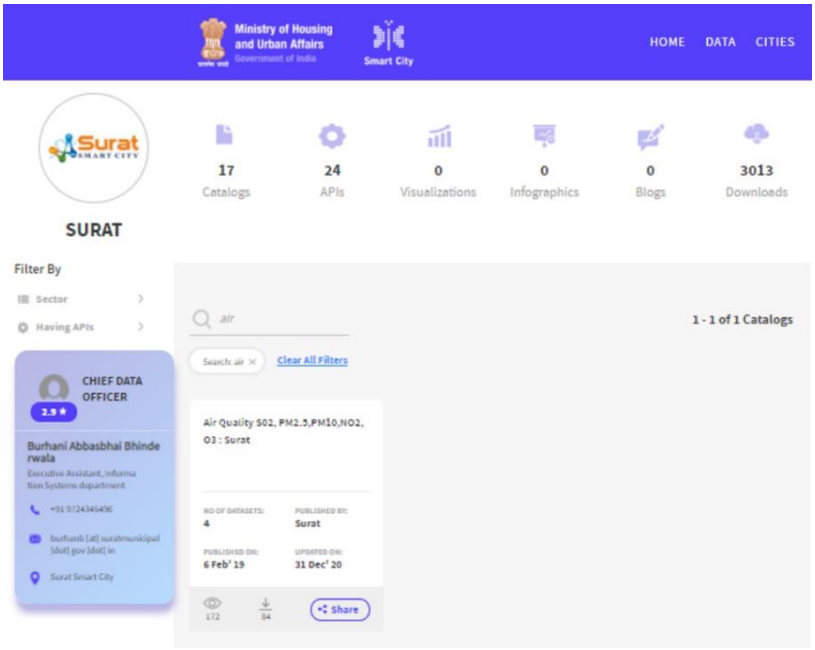

Figure 1. Real time air quality index

2. METHODOLOGY

Study of existing air quality monitoring infrastructure and legislation were conducted to understand the present scenario of air quality monitoring system in Rajkot city. Literature review was done to understand the background of the subject. Research questions were created based on literature review to make research work more focused. For exploring the role of air quality monitoring system and utilization of real time data, best case practices study was done for the Indian as well as International cities. Air pollution monitoring process and it's utilization in last three years with stakeholder consultation helped understand the process and its efficiency

2.1. Problem Statement

Air quality monitoring system plays vital role to know the air pollution level in comparison with government guidelines in real time. Guidelines on air quality by the Centre Pollution Control Board are set for all air pollutants to measure and create target to advance better air quality. Efficient monitoring system alerts citizens in case of any extreme events in the city to take mindful action. As observed, air pollution differs in different areas of the city due to

reasons like industrial emission, traffic congestion and waste burning and to know specific reasons behind pollution in different locality, monitoring with source identification is important aspect. This process guides to identify severe hotspots in order to take actions for better air. Therefore, it's very important to have efficient pollutant monitoring mechanism in place for the better surrounding. This research work explains the existing air quality monitoring system at Rajkot.

2.2. Research Objective

- Understanding the role of technology in existing air quality monitoring system at Rajkot.
- Studying the various technology used in air quality monitoring system.
- Exploring best case practices for optimization of air monitoring infrastructure.

3. LITERATURE REVIEW

Air pollution is considered as a one of the greatest threat to urban area, which cases around seventy lakhs death worldwide every year. WHO's health impact assessment explains that only one out of ten people breathe good air quality whereas nine people breaths air that doesn't fulfil the air quality standards and it has high pollutants se-verity which is harmful for the health [7]. Because of pollutants throughout the cities to indoor pollutants, pollution is harmful for individual's health and environment. Indoor and outdoor pollution's combined effect have caused seventy lakhs death each year which is more severe than diseases like heath, lung cancer, etc. Hence, it's very important for cities to have efficient air quality monitoring system in place to measure air level in each area and take appropriate actions based on monitoring results.

Table 1. Health impacts of poor air quality

AQI	**Associated Health Impacts**
Good [0-50]	No risk
Satisfactory [51-100]	Minor breathing problem for vulnerable people
Moderate [101-200]	Breathing problem to the people having history of lung dis-ease (Includes old age, adults and children)
Poor [201-300]	Breathing issue to citizens having prolonged exposure and health issue of minor breathing to citizens having heart dis-ease with short exposure
Very poor [301-400]	Respiratory illness to the citizens having prolonged exposure.
Severe [401-500]	At this level causes respiratory problems on healthy citizens, severe health issues on citizens having lung/heart diseases.

This real time monitoring requires environmental sensors to monitor air pollutants which includes dust particles, PM 10, PM 2.5, No2, Co2, CO, and So2 levels. Also, this information on air pollutants level can be accessed by the citizens via government website, smartphones, app etc. This technology gives a platform to citizens to monitor live air quality level in their respective locality. Hence, this technology implementations provides better quality of life to citizens and enables them to take appropriate actions [8]. As it is explained in Table 1, for severe category level it may cause sever health problem for healthy people. To monitor severity of air pollutants, environmental sensors are placed at the strategic location which includes on top of buildings, near to traffic, industrial areas, and residential areas. This environmental sensors collects data and the transfers it for further analysis. The result of analysed data is updated regularly on public platform for the citizen. This wireless environment sensors are put strategically at various locality to

captures the level of dust particles, CO2, NO2, CO, and SO2 in the surroundings. For further analysis data is being transferred to a gate-way which forwards it to a database through various communication mode like WiFi communication or means of cellular. After that analysis process is done to know severity of various air pollutants at various locations. The live air pollutants data is shown to citizen via government portal. This enables the citizen or related govern-men body to prepare details on corrective measures and the citizens for precaution-ary actions in case of any extreme events. It gives efficient one click solution to the citizens to monitor severity of air pollutants in respective locality. This entire mechanism has cost viable and easily available tools such as a gas sensor and dust sensor. These sensors are controlled by microcontrollers which acts as a transmitter to transfer the air pollution data. The program directs microcontroller to receive inputs from the environmental sensors and process it further [9].

3.1. Seoul case study

Rapid urbanization and extensive industrialization have been part of South Korea's growth in last few decades and it is seen in the exceptional economic growth. Due to the consequences of this, level of air pollution has increased in urban areas. Air pollutions is has increased in areas like Seoul, Busan due to growth in vehicle movement, industrialization etc. Monitoring was essential in this scenario to know the severity of pollutants in Seoul at several locations which lead to having the real time air pollutant monitoring mechanism for data of air pollution in the city. This system also forecasts and creates warning to citizens in terms of health impact based on analysis. The data generated form system are being used for evaluating efficiency of policies to curb air pollution, analysis of weather situation and trend. It also helps in creating air pollutants trend analysis for particular time or season. Stations from various locations in Seoul presents air quality scenario and characteristics for detailed analysis. Table 2 & Fig 1 shows, how System automatically measures air quality level in real time, and further results being analysed at the city's respective department, and then final analysis comes out on government's website for the general public [10].

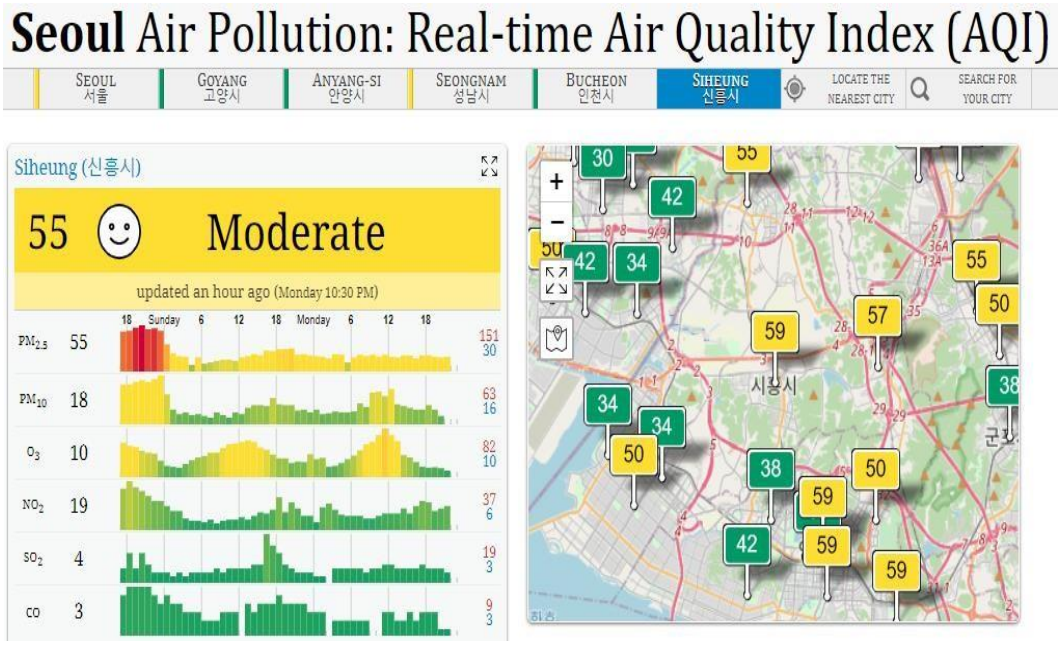

Figure 2. Real time air pollution data

Table 2. Details on alert based on pollution level

Pollutant	level	Notifying the alert	Criteria
PM10	Observe	Considering various aspects of weather, when an automatic measurement station's hourly density of PM 10 > 150$\mu g/m^3$ for minimum 2 hours.	Parameters in particular areas that have already had a 'alert' notified,
	Alert	When an automatic measurement station's hourly PM10 density > 300$\mu g/m^3$ for at least 2 hours.	Considering the parameters of weather in particular areas that have already had a 'alert' notified, when an automatic measurement from sensor (hourly) PM10 density is < 150$\mu g/m^3$,
PM2.5	Observe	When an automatic measurement station's hourly PM2.5 density > 90$\mu g/m^3$ for at least 2 hours.	'Alert' issued, when an air quality level from station's hourly PM2.5 density < 50$\mu g/m^3$.
	Alert	When an automatic measurement station's hourly PM2.5 density is higher than 180$\mu g/m^3$ for at least 2 hours	'Alert' issued, when an automatic air quality data from station's hourly PM2.5 density < 90$\mu g/m^3$ then 'notification' changes to 'alert'.

Seoul uses air quality monitoring system to monitor the pollutant and then based on data received, forecasting scenarios to issue an alert for the public. The local government continues to expand new monitoring sensors, upgrading existing system, Updating latest features and emphasizing to have fully integrated mechanism on air quality [11].

3.2. Singapore case study

The emission from industries motor vehicles are main source of air pollution in Singapore. Also, air quality is affected by transboundary smoke haze from land and forest fires in the region, particularly during the monsoon. The government has considered a strategy of integrated urban and industrial planning, to reduce air pollution. Additional control measures include air quality monitoring, legislation and strict enforcement. Fig 2 & 3 show, Singapore air quality level is better than many cities in Asia which is comparable with that of cities in the United States and Europe. Singapore follows Pollutant Standards Index which has remained in the 'Good' and 'Moderate' range during 2019. Due to consistent assessment, day to day monitoring and efficient interventions overall Air Quality Management is considered as one of the best system [12].

Figure 3. Real time air pollution data

PSI Value	Air Quality Descriptor
0 - 50	Good
51 - 100	Moderate
101 - 200	Unhealthy
201 - 300	Very unhealthy
Above 300	Hazardous

Figure 4. PSI norms

4. ANALYSIS

4.1. Existing air quality monitoring system at Rajkot

Air monitoring system plays a vital role in controlling air pollution. It gives direction regarding actions for taking necessary steps for air pollution. It has 3 steps which includes,

1. Deploy: Environmental sensors needs to deploy in various parts of the city to get comprehensive analysis of air pollution. This sensors gives pollution data of various pollutants as well as climate data.

2. Analyse: Based on data from various environmental sensors, Data needs to analyse to make It meaningful because data can't work itself. This analysis helps in assessing situation of air pollution in a city. This analysis can be done by using various tools and software.

3. Warn: Analysis will give suggestions associated with health. This can be used to warn citizens regarding severity of air pollution in particular area of the city.

To measure air quality in a comprehensive manner the Air Quality Index (AQI) started in 2015 under the Swatchh Bharat Mission for 14 cities and now it started in 71 cities in India [13]. This index includes 8 air pollutants. AQI is considered as one type of tool to communicate information regarding air quality scenario easily. It converts air pollution data of various pollutants into an index value. This index has six categories. Each category is associated with their health impacts. This health impacts is also explains effectiveness of AQI based on age group. The AQI and health parameters are calculated for eight pollutants (NO2, SO2, PM 10, O3, NH3, PM 2.5, CO) for which 24-hours average of air quality standards are prescribed.

Figure 5. Environmental sensors

Figure 6. Integrated Command and Control Centre (ICCC)

On 21st September, 2017 “Eye Way” project was started, under this projects around 50 environmental sensors were deployed by Phoenix in collaboration with Honeywell. Rajkot has won safe city award 2018 for this project. Fig. 4 shows existing status of environmental sensor and Fig. 5 shows visualization in ICCC center. Fig 6 shows procedure of visualization on data collected from various sensors at ICCC every day. Honeywell and Phoenix deployed these sensors across Rajkot smart city [14]. These devices collects data from different areas like commercial places, residential areas, industrial and traffic signals. Collected data is transferred to cloud platform through Wifi, GPRS. This data is visualized through software and it is put in public display system.

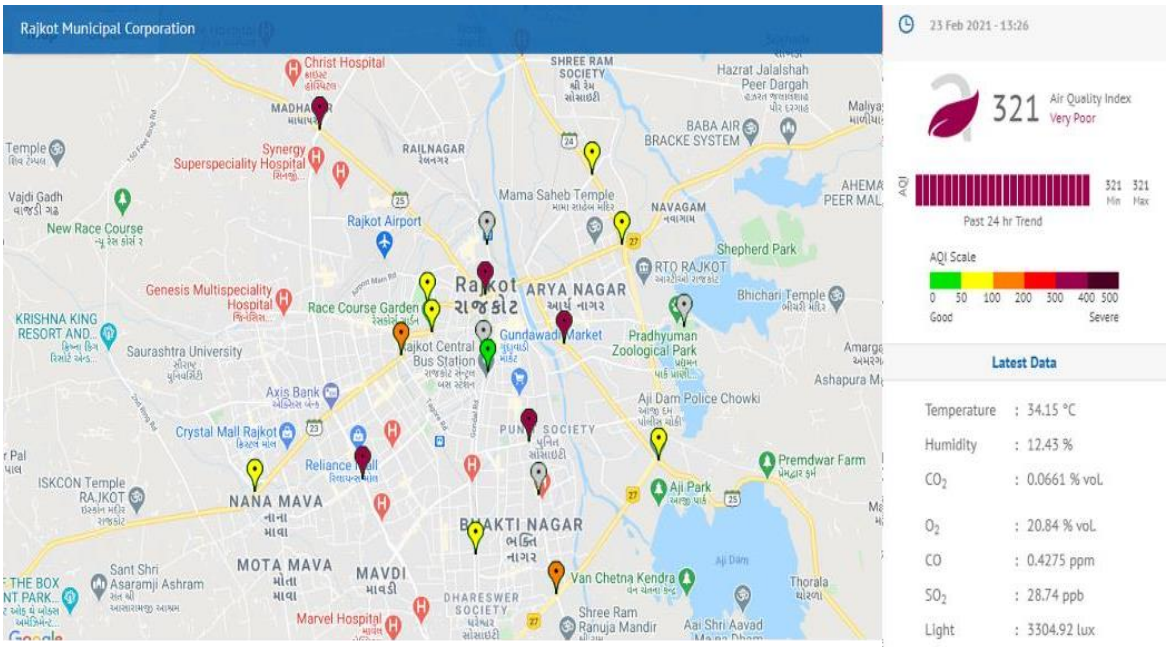

Figure 7. Real time air quality monitoring at Rajkot

Figure 8. Air quality monitoring procedure at Rajkot

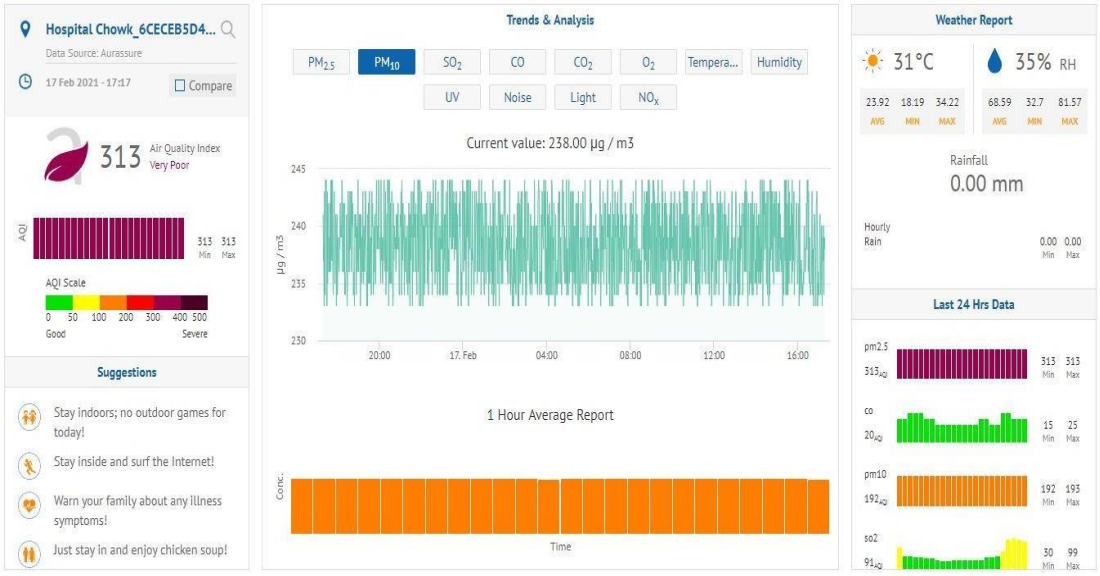

Figure 9. Dashboard for analysis of air quality parameters (PM 10) for Rajkot

Major four types of sensors were seen. These are sensors types and operating principle:

• Electro-Chemical Gas Sensors: It measures the severity of a particular gas by using the process of oxidizing or measuring the electrode by reducing the particular gas. Measuring Parameters: CO, NO2, O3, SO2

• Non-Dispersive Infrared Sensors: The most important component of these sensor is infrared lamps, a sample chamber/light tube & infrared detectors. The IR light is directed towards the IR detector passing through the air chamber. Measuring Parameters: CO2

• Laser Dust Sensors: These laser sensors use a laser scattering theory. Laser or light scattering principle is applied here to derive the exact number of suspended particulate matter per unit volume of air. Measuring Parameters: Particulate Matters (PM1.0, PM2.5, PM10)

• Ultrasonic Sensors: These ultrasonic sensors measure water and inundation level by using ultrasonic waves. The sensors emit ultrasonic waves which are reflected back after hitting the target (water) and is again received back by the sensor [16].

Fig. 8 & 9, explains the trends and analysis of various pollutants on 17 Feb 2021. Based on data of air pollutants collected from various locations. Wherever AQI was very high, it gives suggestions related to associated health effects for particular AQI. This inference helps citizens in taking precautionary measures for particular areas where air pollution is very high [17].

Figure 10. Dashboard for analysis of air quality parameters (PM 2.5) for Rajkot

5. CONCLUSION

Development plays a vital role in forming a city's economy. Over the past few years, Rajkot has developed at a rapid rate, this rapid development has caused increase in air pollution. Though city has air monitoring infrastructure in place, further utilization is required in terms of analysing the data captured from environmental sensors and taking actions based on analysis. Also, real time alerts related to air quality level would help citizen to take precautionary measures. Based on severity of air pollution various methods can be utilized in order to notify people. Utilization of big data and AI would give predictions related to air quality severity which would help in decision making for precautionary measures by local government.

ACKNOWLEDGEMENTS

I would like to express my gratitude to Dr. Gayatri Doctor for consistent support and guidance throughout the research work. I convey my gratitude to Mr. Chetan Nandani for his insightful inputs. I express my profound thanks to Mr. K P Dethariya for his timely help in providing data. With deep sense of gratitude I acknowledge the constant support of my classmates during this research work. I would like to thank my parents for always helping me during this research work. I am grateful to officers from Rajkot Smart City Development Limited for providing data and guiding me to shape this report successfully. I am extremely thankful to professors at CEPT University for providing valuable inputs to enhance this research work.

REFERENCES

[1] CEEW, *"Pathways to National Ambient Air Quality,"* CEEW, New Delhi, 2019.

[2] STEPS, "2. STEPS Centre . (2020, 10 26). /blog. Retrieved 5 20, *Transformation in a crisis reflections on research and action,"* STEPS Centre , 2021.

[3] The Intergovernmental Panel on Climate Change (IPCC), *"Climate Change Synthesis Report," Geneva,* 2014.

[4] UNITED NATIONS, *"CLIMATE CHANGE AND URBANIZATION: EFFECTS AND IMPLICATIONS,"* New York, 2008.

[5] Business standard, "businessstandarsarticle/ government press release," 2014. [Online]. Available: https://www.business-standard.com/article/government-press-release/national-air- quality-index-aqi-launched-by-the-environment-minister-aqi-114101700961_1.html. [Accessed 21 09 2021].

[6] Data.gov.in, "Data.gov.in /resources," 10 2020. [Online]. Available: https://data.gov.in/resources/real-time-air-quality-index-various. [Accessed 23 09 2021].

[7] World Bank Group, " who.int/health.," 2015. [Online]. Available: https://www.who.int/health-topics/air-pollution#tab=tab_1. [Accessed 06 09 2021].

[8] Keysight technologies, "keysight.com," 4 2019. [Online]. Available: https://www.iotchallengekeysight.com/2019/entries/smart-land/211-0515-025039-real-time- air-quality-monitoring-system-based-on-io. [Accessed 08 09 2021].

[9] CPCB , "National Air Quality Index Delhi," CPCB, New Delhi , 2014.

[10] Ministry of environment , "Air Quality Measures south korea. Seoul," Ministry of Environment , Seoul , 2016.

[11] Seould Solutions , "seouldsolutions/content.," 11 2017. [Online]. Available: https://seoulsolution.kr/en/content/6540. [Accessed 6 9 2021].

[12] National Environment Agency, "nea.goc.sg:," 2019. [Online]. Available: https://www.nea.gov.sg/our-services/pollution-control/air-pollution/air-quality. [Accessed 6 9 2021].

[13] Phoenixrobotics, "Phoenixrobotiphoenixrobotix.com Retrieved 03 10, 2021, from phoenixrobotix:," 2017. [Online]. Available: https://phoenixrobotix.com/amp/rajkot-smart- city. [Accessed 27 09 2021].

[14] Smart city council, " smartcities council," 2017, 5 9. [Online]. Available: https://india.smartcitiescouncil.com/article/rajkot-eye-way-project-keep-eye-public-services- and-traffic-management. [Accessed 2021].

[15] Urbanemissioninfo, "/Rajkot," 2018. [Online]. Available: https://urbanemissions.info/india-apna/rajkot-india/. [Accessed 12 09 2021].