Tin Dioxide Sensor Array Network for Air Quality Monitoring

Kavita K. Ahuja#[1], N. N. Jani*[2]

#1 Asst. Prof. Kavita Ahuja, Vimal Tormal Poddar BCA College, Surat, India

*2 Ex-Director, SKPIMCS - MCA, Gandhinagar, India

Abstract — *This review paper presents a sensor network for outdoor air quality monitoring whose nodes includes sensor array which capture the air pollutant gases measurement with CO2 calibration using sensors which are located at different locations of urban city of Gujarat state of India. This calibration is performed on period of time of the year 2016 with daily basis. The research is considered on the analysis of pollutant gases which emits from industries and vehicles are CO2, CO, NO2. Gas concentration values are plotted on graphs to make better and efficient analysis. The main objective of the work is to increase awareness and alertness for people of urban areas towards their health life in aspect of the air which they take while breathing.*

Keywords — *Air Quality, Sensor network, Urban Area*

I. INTRODUCTION

Air is one of the essential elements for the human to be lived healthy, for the plants to grow up and for the animals. Air quality measurement and the prevention to not to be reached on its uncontrolled level results in the prevention of growing number of natural disasters such as heavy rain cloud storms, global warming, wreckages flow, etc. That causes the rising of greenhouse gases on the earth [1]. Most recent assessments shows that polluted air as the 9th largest Global Burden of Disease[2] which increase the frequency of harmful respiratory effects like lung cancer, asthma attacks, heart attacks etc.

The development of indexed for measuring the air quality with respect to air pollution in urban areas is become the crucial thing over the past half century. Air quality can be expressed by the concentration of several pollutants such as Carbon Dioxide (CO2), nitrogen Dioxide (NO2), Carbon Monoxide (CO). The development of indexes for measuring the air pollution in urban areas is named as: air quality indexes (AQI) or air pollution indexes (API) [3]. Both the developed and developing countries have been developing air quality monitoring stations in the city for preventing the effects of air quality.

The sensing nodes are designed and implemented to perform the air quality (AirQ) monitoring using low cost gas sensors and, at the same time, to get the additional information about the temperature (T) and relative humidity (RH)[4]. This information is used to obtain the temperature and humidity to help in globally expressing the air quality.

Most of these air quality monitoring stations have been using primitive methods of monitoring air quality, such as collecting air samples and analysing those samples in laboratories. These methods are reliable but inefficient and expensive. Basically, analytical instruments such as Spectrometers and gas chromatographs may be used but they suffer from the same disadvantages as the primitive methods and they also require skilled professionals to operate them. We need a comprehensive approach for the real-time monitoring of air quality to reduce the impacts of climate change.

Smart sensor-actuated network has taken dynamic role in replacement of instruments. We have established and used smart network in urban city for measurement of air quality. A Kumar et al. has introduced air pollution measurement parameters such as CO2, CO, and NO2 with the wireless environment monitoring processor [5]. Jelicic et al. presented a method of monitoring of these parameters with the help of a wireless sensor network and infrared gas sensor. They also introduced techniques for how to decrease the energy consumption in the remote sensor, network and node [6].

The amount of Air quality monitoring data is depend on what number of sensor nodes we are installed and implemented in targeted area. Several pollutants are generally monitored by each station and hourly or daily average attention data are calculated. Therefore, air monitoring networks provide a large mass of data. Being located on the Southern part of Gujarat of India between 21‟ to 21.23‟ degree Northern latitude and 72.38‟ to 74.23‟ Eastern longitude Surat is the second largest commercial hub in the State. Surat is mainly known for its textiles and diamond cutting & processing industries. Nowadays, it is emerging as a potential hub for IT\TeS sector in Gujarat. Hajira and Magdalla Ports in the district provide logistic support to the industrial operations min the state with foreign countries [7]. The Table I shows the industrial status of Surat city with its urban areas like Sachin, Pandesara, Surat Apparel Park, Bardoli, Ichhapore-Bhatpore, Kawas, Hazira-mora, Khatodara, Olpad, Katargam, and RingRoad.

TABLE I
Status of Industrial Estate in Surat District

Name of Industrial Area	Land Acquired (Hac.)	No of Plots	No of Allocated Plots	No. of Units Production
Pandesara	218.27	547	545	782
Katargam	38.33	54	54	887
Sachin	749.35	1557	1553	2075
Hazira-Mora	428.04	4	4	4
Khatodra	3.08	43	43	142
Olpad	31.59	70	70	68
Ichhapore-Bhatpore Kawas	919.84	323	298	337

In this article the Air Quality currently adopted by the network which we have established, was applied to the metropolitan city of India in order to analyse the trends in air quality from October 2016 to December 2016. The data of mostly industrial areas are provided by the Surat Municipal Corporation (SMC), which is rapidly increased in upcoming for years.

II. Methodology

A. *The Air Quality Index*

The AQI is a measurement to represent the overall state of the air pollution of that area. The numerical value of the index may fall into 6 classes of judgment of air quality, reported in Table I, associated with the different colors in order to make this information easily transmitted to the public.

The AQI considers measurement of pollutants air that present in air which effect on human health (PM10, PM2.5, CO, NO2, O3, and SO2). There are six AQI categories, namely Good, Moderate, Poor, Very Poor, and Severe.

The proposed AQI will consider eight pollutants (PM10, PM2.5, NO2, SO2, CO, O3, NH3, and Pb) for which short- term (up to 24-hourly averaging period) National Ambient Air Quality Standards are prescribed. This index is purpose of giving daily information to prevent from the cause of short-term harm.

In this work the values of the concentrations used in the calculation of air pollutant elements measure in [ppm] or [ppb] in order to properly implement the EPA's table of breakpoints. In the calculation of the

AQI the PM2.5 is not considered because the monitoring stations do not acquire Concentration values for that pollutant. We have used measurement of pollutant gases such as CO2, CO, NO2. The value of AQI is defined in [8]. These values are given in Table II gives the air quality levels. The values can used to compare the level of air pollution and health implications on the people.

Table 3 gives the brief of parameters of our work and their accuracy should be maintained. This are parameters are base of calculation of air pollution in the environment. The temperature and relative humanity is proposed to the value of pollutant gases in the environment. The range defines the probability for the values of defined parameters to be fall on. The accuracy defines that the percentage values to be acceptable for data set used for efficient analysis.

TABLE II
Air quality Level and health Implications

AQI	Air Pollution Level	Health Implications
0 – 50	Good	Air quality is considered satisfactory, No risk
51 -100	Satisfactory	Air quality is acceptable; however, may cause minor breathing discomfort to sensitive people
101-200	Moderately polluted	May cause breathing discomfort to people with lung disease such as asthma, and discomfort to people with heart disease, children and older adults.
201-300	Poor-Unhealthy	May cause breathing discomfort to people on prolonged exposure, and discomfort to people with heart disease
301-400	Very Poor-Very Unhealthy	May cause respiratory illness to the people on prolonged exposure. Effect may be more pronounced in people with lung and heart diseases.
401 +	Hazardous	Health alert: everyone may experience more serious health effects

TABLE III
Air pollution Base parameters

Parameter	Unit	Range	Accuracy
Temperature	°C	0 – 50	± 0,3 °C
Relative Humidity	%	10 – 90	± 3 % (for 30…70 % RH at 20 °C) ± 5 % (for 10…90 % RH at 20 °C)

Carbon Dioxide	ppm	0-2000	< ± 50 ppm +2% of measuring value (at 25 °C and 1013 mbar)
Carbon Monoxide	ppm	0-99	9< ± 1 ppm (at 20±5 °C / 50±20 % RH)
Nitrogen Dioxide	ppm	0-10	< ± 1 ppm (at 20±5 °C)

B. *The Data Source*

The data of the concentration of pollutants captured from the monitoring network of the Surat city of Gujarat state of the India. Surat is the 2nd largest city of Gujarat in area and population. This is spread wide in area of 326.51 sq. km. We setup the CO2 calibrated sensors covering all 7 zones. Figure 1 shows the stations of monitoring system.

Fig. 1: Air Quality monitoring Locations of the sensor nodes of the study site

The nodes are setup in different stations like Pandesara, Katargam, Ringroad, Udhna, Jahagirpura, pal gaam, Kumbhariya etc. The nodes collect data using sensor with CO2 calibration on daily basis and hourly basis and send them to the base sink node which is setup in Varachha area is a place where data analytics is going to perform.

Each station is serious of analyser's independent from each other and capable of measuring the pollutant gases (CO2, CO, NO, CH4) and other status of environment situation like Dust, Humidity, and Temperature. The analyser under go with those data capture with this stations with the four months of the year 2016 i.e. from September to December.

III. RESULTS AND ANALYSIS

As shown in the graph of Figure 2, the concentration of CO2 and other gases have been capture and analysing processing on that took place at the lab centre. The locations of the three monitoring stations are unchanged during the period of research. The attributes that are considered by monitoring sensors are as following:

>names (file_pandesara)

"Id" "Device_Id" "Temperature" "Humidity" "Dew_Point" "Light" "UV" "CO2" "CO" "NO2" "CH4" "Battery_Voltage" "Solar_Voltage" "Noise" "Dust" "Device_Date" "Entry_Date"

Among these following attributes of located sensors we have chosen the pollutant gases i.e. CO2, CO, NO2 as our research parameters for air quality measurement.

The monitoring station is selected where the probabilities of high industries and vehicular traffic is present. We have considered three areas (pandesara, ringroad, katargam) of urban city among all the domains of research fields.

The graph in Figure 2 shows the CO2 concentration falls in the range of 400 ppm on daily basis. This measurement can also be applied to other research stations also. The box plot graph shows the date wise CO2 concentration in pandesara area in the month of October which shows that every day the CO2 range is change its values.

The dataset of those areas is presented in Table IV and in Table V are:

TABLE IV

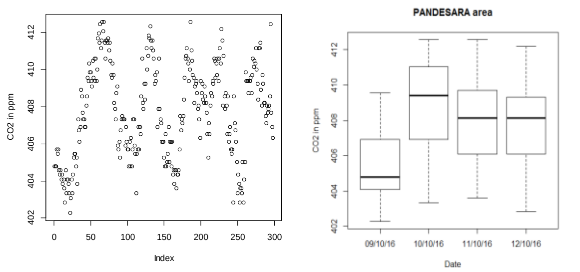

Fig. 2(a): CO2 concentration of pandesara area (b) Distribution of daily Co2 concentration

Data set of Ringroad Area

Ringroad.csv

Date	*CO2*	*CO*	*NO2*
September-2016	*201.00*	*81.67*	*20.67*
Octomber-2016	*380.12*	*49.81*	*15.78*
November-2016	*275.78*	*40.45*	*83.60*
December-2016	*421.37*	*56.43*	*78.45*

The above parameters are represented in graphically shown in Figure 3 which gives the brief information that CO2 which is increased in every month in industrial areas.

TABLE V
Data set of pandesara Area

Padesara.csv

Date	*CO2*	*CO*	*NO*
Sep-16	*280.67*	*32.60*	*20.67*
Oct-16	*350.14*	*35.60*	*18.60*
Nov-16	*389.70*	*20.60*	*10.60*
Dec-16	*407.62*	*10.70*	*13.60*

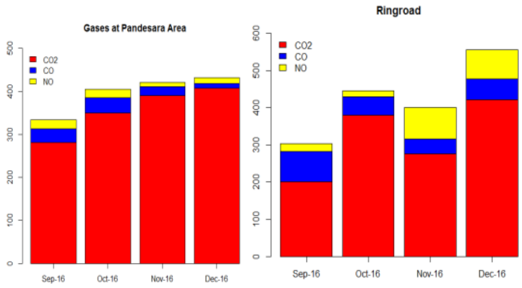

Fig. 3: (a) CO2 concentration at Pandesara
(b) CO2 concentration at Ringroad area

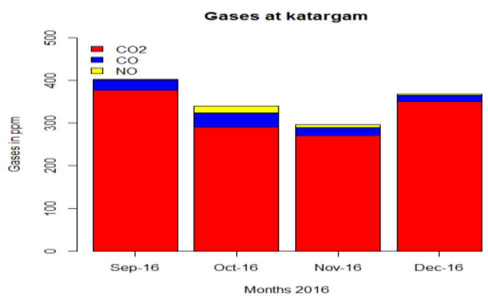

Fig. 4: CO2 concentration at katargam

The monthly air quality report shows that in December month the ratio of air quality pollutant gases become high concentration. Here, the gas NO has lowest concentrate with

Compare to other gases during all period for analysis months.

TABLE VI
Quarterly frequencies of three monitoring station

Station	**Months**	**Air Quality pollutant Risk (%)**
Pandesara	September	3.34
	October	4.04
	November	4.21
	December	4.32
Ringroad	September	3.03
	October	4.46
	November	4.00
	December	5.56
Katargam	September	3.82
	October	3.86
	November	3.83
	December	3.83

The values of the frequency of related station of city is summarize in Table VI. Every month has a risk of air pollution to be raise. Here, the pandesara area has a risk of air quality to be pollutant in month of December is 4.32%.

IV. CONCLUSION AND FUTURE RESEARCH

In this article we have applied the Air Quality measurement and their risk of to be pollutant in future which effect on human life and health which is adapted by the United States Environmental Protection Agency, to the metropolitan city of Gujarat. The trends of air quality were analyzed from September 2016 To December 2016 using the data of pollutant concentrations provided by the Surat Municipal Cooperation.

From the analysis of the data related to the three monitoring stations in the industrial areas, it was possible to calculate the trend frequency of pollutant air also identified the central category and the air quality present in groups where the monitoring stations are located. In detail, the monitoring stations are in the category of "Good" and "Moderate"

Future development of our work aims to monitor air quality continuously and find the precaution for air quality that not to exceed from haphazard in the country for making human life harmless and secure.

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