ISSN:2348-2079

Volume-7 Issue-2

International Journal of Intellectual Advancements and Research in Engineering Computations

IOT Based Real-time Monitoring System of Atmospheric Gases Using Arduino Uno

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ABSTRACT

Air Pollution is the world's largest single environmental health risk, which is mostly due to the pollutants of Particulate matter of aerodynamic size from 2.5 micrometres to 10 micrometres, which are emitted mostly by burning coals, plants, heavy metals and other petrochemical products. Quality of the air in city and urban areas is the most important factor that directly influences the incidence of diseases and decreases the quality of life. Taking appropriate decisions in a timely period depends on the measurement and analysis of the parameters of the air, which creates the need for the development of real time air quality monitoring. The use of air quality monitoring systems makes it possible to do a detailed level analysis of major pollutants and their sources. These monitoring systems are important components in many smart city projects for monitoring air quality and for controlling the main pollutant concentrations in urban areas. In this paper we present an approach for cost-effective measurement of relevant environmental parameters, based on a scalable sensor array. The measure air quality is updated to cloud and data is processed to find the level difference in each area depending on number of trees in that area, because trees absorb harmful gases such as sulphur dioxide, carbon monoxide, carbon dioxide along with PM particles of various sizes.

Keywords: Arduino Uno R3, MQ135 (Sensor to detect AQI), Connector for data transfer, Male to female breadboard wires.

INTRODUCTION

Clean air is one of the basic requirements for good human health and wellbeing of the humanity. Air pollution continues to be a well-known environmental problem worldwide. It can pose a serious threat to human health if it exceeds the permissible limit (WHO, 2000; USEPA. 2008). The quality of the air is the result of complex interaction of many factors that involve the chemistry and the meteorology of the atmosphere, as well as the emissions of variety of pollutants both from natural and anthropogenic sources. According to a World Health Organization's (WHO) assessment of the burden of disease due to air pollution, more than two million premature deaths per year can be attributed to the effects of urban (outdoor /indoor) air pollution that is mainly caused by burning of solid fuels (WHO,2000, 2002, 2005). More than half of the air pollution driven disease burden is borne by the population of developing countries (WHO, 2005). The WHO air quality guidelines are intended for worldwide use but have been developed to support actions to achieve air quality that protects public health in different contexts.

Globally, air quality guidelines are designed to offer guidance in reducing the adverse health impacts of the air pollution. These guidelines are based on expert evaluation of the studies on the health effects of air pollution and current scientific evidence. These guidelines are intended to suggest policy-makers about the gravity of the air pollution problem and to provide appropriate targets for a broad range of policy options for air quality

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management in different parts of the world (WHO, 2002, 2005; USEPA, 2008).

Air quality standards are set by individual countries to protect the public health of their citizens and as such are an important component of national risk 2 management and environmental policies. For purpose of setting Air Quality Standards, air pollutant concentrations should be measured at such monitoring sites that are representative of population exposures. Air pollution levels may be higher in the vicinity of specific sources of air pollution, such as roads, power plants and large stationary emission sources. So, the protection of populations living in such situations may require special measures to bring the pollution levels to below the guideline values. National Air Quality standards will vary according to the approach adopted for balancing health risks, technological feasibility, economic considerations and various other political and social factors, which in turn will depend on, among other things, the level of development and national capability in air quality management. The Air Quality Index (AQI) is a scale designed to help one understand what the air quality around one means to one's health. It is a health protection alarming tool that is designed to help one make decision to protect one's health by limiting short-term exposure to air pollution and adjusting one's activity levels during increased levels of air pollution. It also provides advice on how one can improve the quality of the air one inhales. This index pays particular attention to people who are sensitive to air pollution and provides them with advice on how to the protect their health during air quality levels associated with low, moderate, high and very high health risks. The AQI reports current air quality based on a specific level of an individual air pollutant. The AQI communicates primarily a number from 1 to 500 indicating the quality of the air. The higher the number, the greater the health risk associated with the air quality. When the level of air pollution is very high, the number will be reported above 300.

DESCRPITON OF BACKROUND

Air is an important aspect of life, which is because we cannot avoid breathing in the air around us. An average person breathes 20 - 30 times per minute. The air around us is a mixture of gases and small solid and liquid particles. Polluting that type of atmospheric substances can cause increase in high concentration above the normal ambient levels to produce measurable effects on man, animals, vegetations, materials, etc. Thus, it has been a widely recognised problem around the world. The wide variety of air pollutants form activities like burning of fossil fuels, coal and oil to power, industrial processes and automobiles emits carbon monoxide (CO), oxides of nitrogen (NOx), volatile organic compounds (VOCs), particulate matter (PM) and sulphur dioxide (SO2) etc.,

METHODOLOGY

An AQI is usually used by government agencies to monitor the level of pollutants in the air currently is and predict how it can become in future. As the AQI increases, an increasingly large percentage of the population is likely to experience severe adverse health effects. AQI is an "index" determined by calculating the degree of pollution in the city or at the monitoring point and includes the major pollutants like Particulate Matter (PM 2.5), Particulate Matter (PM 10), Sulphur dioxide (SO_2), Nitrous Oxide (NO_x), Carbon monoxide (CO), Ozone (O_3), and Ammonia (NH_3). Each of these pollutants have an air quality standard which is used to calculate the overall AQI of the operational area.

In numbers. AQI is represented between 0 to 500, where 0 to 50 is considered to be good air with minimal impact. Values ranged 51 to 100 defines satisfactory and cause minor breathing discomfort to sensitive people. Values between 101 and 200 is a moderate which leads breathing discomfort to the people with lung, heart disease, children and other adults. Values ranged 201 to 300 falls in poor category where breathing is discomfort for people on prolonged exposure to the affected air. When the values are between 301 to 400 it causes respiratory illness to the people who were exposed to the air tediously. If the values exceed 400 limits, it even causes respiratory issues to healthy people.

Taking care of trees, maintaining existing trees, and planting trees are the most predominant factor

of the proposal. These factors are termed to be as Urban forestry. It helps to improve our air quality. Heat emitted from earth is trapped in the atmosphere due to high levels of above-mentioned gases that prohibit it from releasing the heat into space. Thus, leads to "Greenhouse effect" and cooldown earth by the process of evapotranspiration. Trees and even some types of flowering plants in South America like petunia plants absorb air pollutants like O_3, SO_2 and NO_2. But even trees give ozone (which causes smog in earth surface) it is important to plant right variety of trees.

AIR QUALITY INDEX (AQI)

The Air Quality Index (AQI) is a scale designed to help one understand what the air quality around one means to one's health. It is a health protection alarming tool that is designed to help one make decision to protect one's health by limiting short-term exposure to air pollution and adjusting one's activity levels during increased levels of air pollution. It also provides advice on how one can improve the quality of the air one inhales. This index pays particular attention to people who are sensitive to air pollution and provides them with advice on how to the protect their health during air quality levels associated with low, moderate, high and very high health risks. The AQI reports current air quality based on a specific level of an individual air pollutant. The AQI communicates primarily a number from 1 to 500 indicating the quality of the air. The higher the number, the greater the health risk associated with the air quality. When the level of air pollution is very high, the number will be reported above 300.

Table: Air Quality Index for different Pollutants as proposed earlier for India

Description	AQI	Color Coding
Good	0-100	
Moderate	101-200	
Poor	201-300	
Very poor	301-400	

AQI Formula

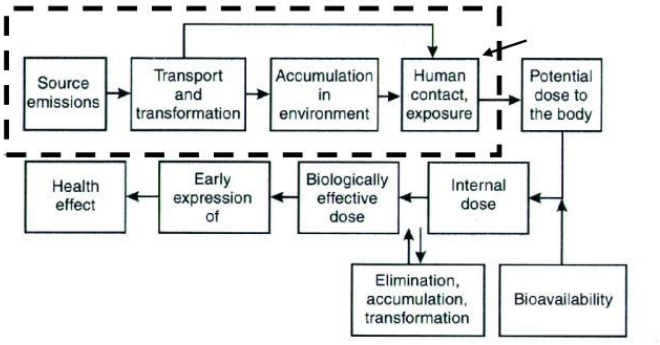
$$I = \frac{I_{high} - I_{low}}{C_{high} - C_{low}}(C - C_{low}) + I_{low}$$

HEALTH VS EXPOSURE TO POLLUTION

Exposure to air pollutants can cause a range of symptoms (Avol, et al., 1998; Delfino, et al., 1998; Wong, et al., 2002; Katsouyanni, et al., 2001; Pope, 2002; Burenett, et al., 2004). People with lung or heart disease may experience increased frequency and/or severity of symptoms, and increased medication requirements. Of course, each individual will react differently to air pollution. Individual reactions to air pollutants depend on the type of pollutant a person is exposed to, the degree of exposure, the individual's health status (immunity) and genetics. Negative health effects increase as air pollution worsens. During high pollution episode, the healthy people may show more resistant than the individual suffering from the pre-existing health problem does. Studies have shown that even modest increases in the air pollution for a short period can cause small but measurable increase in emergency room visit and hospital admissions among sensitive or at-risk people, while healthy individual may not show any effect. However, even healthy people, especially those who work or exercise outside, may have difficulty in breathing when air pollution levels are very high.

The most common categories of people at increased risk are the people who have acute respiratory illnesses such as asthma, chronic obstructive pulmonary disease (COPD), which includes chronic bronchitis and emphysema or lung cancer. The peoples with existing cardiovascular conditions such as angina, previous heart attack, congestive heart failure or heart rhythm problems (arrhythmia or irregular heartbeat) are sensitive to air pollution. People with diabetes are also more sensitive to air pollution because they are more likely to have cardiovascular disease. Air pollution makes it even harder for people to breathe, can make existing lung or heart-related symptoms worse. For example, it can trigger heart attack. Infants and children are especially susceptible to the health effects of air pollution as their bodies and lungs are still in the tender stage. Children, in particular, have greater exposure to air pollution because they breathe in more air per kilogram of bodyweight than adults do and they spend more time outside being active outdoors. Their elevated metabolic rate and young defence systems make them more susceptible to air pollution. Children with asthma or other respiratory diseases are more likely to be affected. Air pollution can trigger asthmatic attack and aggravate symptoms of respiratory ailments like coughing and throat irritation even in healthy children. The elderly people also are more likely to be affected by air pollution, due to generally weaker lungs, heart and defence systems, or undiagnosed respiratory or cardiovascular health conditions. People participating in sports or strenuous works outdoors breathe more deeply and rapidly allowing more air pollutants to enter the lungs. On days when air pollution levels are significantly elevated, even people not in the above groups may develop symptoms of respiratory problems. People who are otherwise healthy may have the symptoms like eye irritation, increased mucus production in the nose or throat, coughing, difficulty in breathing especially during exercise. People with asthma or COPD may notice an increase in cough, wheezing, shortness of breath or phlegm. People with heart failure may experience increased shortness of breath or swelling in the ankles and feet and those with heart rhythm problems may notice increased fluttering in the chest and feeling light-headed. People with angina or coronary artery disease may have an increase in the chest or the arm pain.

Progression of factors that influence the behaviour of a contaminant within the environment, its uptake by humans, and the resulting health effects:



The choice of indicator for particulate matter requires number of considerations. At present, most routine air quality monitoring systems generate databased on the measurement of PM10and not on the size segregated. Consequently, the majority of epidemiological studies use PM10as the exposure indicator. PM10 represents the particle mass that enters the respiratory tract and, moreover, it includes both the course (particle size between 2.5 and 5 μm) and the fine particles (measuring less than 2.5 μm, PM2.5) that are considered to contribute to the detrimental health effects observed in the urban environments. The former particles are primarily

produced by mechanical processes such as construction activities, road dust re-suspension and wind. In most urban environments, both coarse and fine mode particles are present, but the proportion of particles in these two size ranges is likely to vary substantially from one city to another around the world, depending on local geography, meteorology and specific PM sources. In some areas, the combustion of wood and other biomass fuels can be an important source of particulate air pollution, the resulting combustion particles being largely in the fine (PM2.5) mode. Although few epidemiological studies have compared the relative toxicity of the products of fossil fuel and biomass combustion, comparable effect estimates are found for a wide range of cities in both developed and developing countries.

Index	SO_2	NO_2	CO	O_3	PM10
00-100 (Good)	0-80	0-80	0-2	0-157	0-100
101-200 (Moderate)	81-367	81-180	2.1-12	158-196	101-150
201-300 (Poor)	368-786	181-564	12.1-17	197-235	151-350
301-400 (Very poor)	787-1572	565-1272	17.1-35	236-784	351-420
401-500 (Severe)	>1572	>1272	>35	>784	>420

CONCLUSION

It should be noted that the scientific studies and scientific judgment play an important role in establishing guidelines that can be used to indicate the acceptable levels of population exposure which can be helpful and determinable factors for policy makers and implementing agencies. Keeping the above scientific spirit in mind and the fact that it is high time that we make a novel beginning in Air quality forecasting in India through Commonwealth Games (which will be held in New Delhi, India in October 2010), this ambitious scientific report has been proposed and released. Hence, it should be noted that the AQI break points for the Indian environment (and subsequent categorization) is generated as preliminary, based on This report is an outcome of the motivation provided to the authors by the Secretary, Dr. Shailesh Nayak, Ministry of Earth Sciences, Govt. of India through the challenge of SAFAR and we sincerely salute his guiding path. The project SAFA Rand its above-mentioned component could not have been executed and implemented without the whole-hearted support of Prof. B.N. Goswami, Director, IITM, Pune. It had not been possible to make such a detailed science-based criteria evaluation of the Indian air quality exposure guidelines if the SAFAR project could not have been conceived by the ministry (MoES). The kind help extended by Mr.D.P. Singh, Joint Secretary, MoES in the execution of SAFAR project is greatly appreciated. We are deeply indebted to Dr. Swati Basu, Advisor, MoES who remained all along a driving force in implementing SAFAR project and advising us in all stages of the project. I sincerely acknowledge the painstaking review work and valuable comments received from all referees specially Dr. Kausar Ali, Dr. G. Pandithurai, Dr. R. Krishnan, Dr. Chhemendra Sharma (NPL, New Delhi), Prof. Greg Carmichael (USA) and anonymous reviewers which has improved the scientific value and quality of this report substantially. The editorial work of reviews carried out by the Library, Information and Publication (LIP) Division headed by Mrs. A.A. Shiralkar and Editorial Committee chaired by Dr. A.K. Sahai is highly appreciated.

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