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Low Cost Solution for Real Time Air Pollution Monitoring using WSN

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ABSTRACT: Wireless Sensor Network has emerged as a most efficient, scalable and low cost solution for real time monitoring air pollution from widely spread locations. Wireless Sensor Networks has also been widely used by military, healthcare monitoring systems and the manmade/ natural disasters and many other applications. During the past few years, the state of Himachal Pradesh, India, has made remarkable progress in developing new industrial areas with growing population and traffic as well. Such a growth in new industrial establishments has opened up growing opportunities for the citizens, which results a significant increase in the air pollution level. This paper presents low cost solution for real time air pollution monitoring using WSN. The objectives of this paper are: (i) To set up experiment for Air Pollution monitoring using WSN (ii) Real time minute to minute updated status with graph of the air pollution for the citizens.

KEYWORDS: Wireless Sensor Network (WSN), Air Pollution, Arduino

I. INTRODUCTION

During the past few years, Wireless Sensor Network (WSN) has been proved a low cost solution for the critical environmental problems. These problems have been affecting the quality of human life as such. Today, the latest ICT enabled technologies have made the life very easy and comfortable in the age of great industrialization. It is a matter of pride that the latest technologies are very much within the reach of a common man and young generation is using the same very efficiently. But, the other side of this growth is very hazardous and a threat to mankind and environment too. Due to the rapid and intense growth of industrial development, vehicular traffic and high rate of migration of the population to the urban areas along with high levels of power energy consumptions lead to higher rate of increase in air pollution all around. Another irony is that, developing countries are not equipped with the latest technologies in the era of ICT, which can provide the real time information of the data. The current status is, having understood the crucial nature of the pollution, a study of air pollution, level and its growth in the last few years carried out in Shimla, the capital of Himachal Pradesh. In this state, the pollution control board is in existence/ working, with a mission, 'To improve the well being of the people of the state through environmental interventions and to deal with the issues related with pollution in the entire state of Himachal Pradesh, India. H.P. The State pollution control board is trying to measure each of the various aspects of pollutants and reporting this to the concerned agencies [1]. A lot of manual work and processing is involved to generate some relevant information of pollution and still the real time data and its analysis is not available real time air pollution bases. A cloud based wireless sensor network has emerged as a ray of hope to provide solution to these problems. e.g. Community sensor networks [1,3]. Developments like "Sensor-Internet Share and Search" [4] and "People - Centric Urban Sensing networks" [5] are great examples of advancement in this area.

Present status of Air Pollution in Shimla

The World Health Organization (WHO-1999) has defined "Air pollutants" as substances put into air by the activities of mankind, in such concentrations, which are sufficient to cause harmful effect to human health, vegetation, property or to interfere with the enjoyment of property.[3]

Air pollutants change the composition of the atmosphere and affect the biotic environment. Some of the pollutants of concern are particulate matter (smoke, fumes etc); oxides of carbon, nitrogen and sulphur; hydrocarbons; metals; oxygenated compounds (alcohols, aldehydes, acids, etc.); ozone and other oxidants etc. Two general groups of pollutants, based on their nature of formation, have been identified, viz. primary pollutants and Secondary pollutants [3,6].

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- Primary pollutants are those that are directly emitted from the source e.g., Sulphur dioxide (SO₂), Nitric oxide (NO), Carbon monoxide (CO), etc.
- Secondary pollutants are those that are formed in the atmosphere as a result of reactions between normal air constituents and primary pollutants or amongst primary pollutants only, such as Sulphur trioxide (SO₃), Nitrogen dioxide (NO₂), Peroxy acyl nitrate (PAN), etc.
- Another classification of pollutants depending on their nature defines two kinds of pollutants, viz. critical pollutants and hazardous air pollutants. Oxides of sulphur and nitrogen, carbon monoxide, ozone and suspended particulate matter are some of the ‘critical pollutants’.
- Most of the pollutants, related to petroleum production, processing and use, have an intrinsic toxic potential which fall in the ‘Hazardous Pollutants’ category. Their products as a result of photochemical reaction are more dangerous than the original pollutants and may affect biological systems at extremely low concentrations

During British regime, Shimla used to be the summer capital of India and now known as Queen of Himachal Pradesh which has a lot of environmental disturbances due to a large number of tourists visiting with their vehicles. Air pollution data [6] for the last 4 years of this city under study has been presented below for two different sites in Shimla. Site -1 is Takka bench, is situated on the main ridge of the city, where no traffic is allowed and another site is Bus Stand, which is located in the high traffic zone. The complete data is presented in the graph, which clearly depicts that in high traffic zone, higher is the level of pollutants than other site.

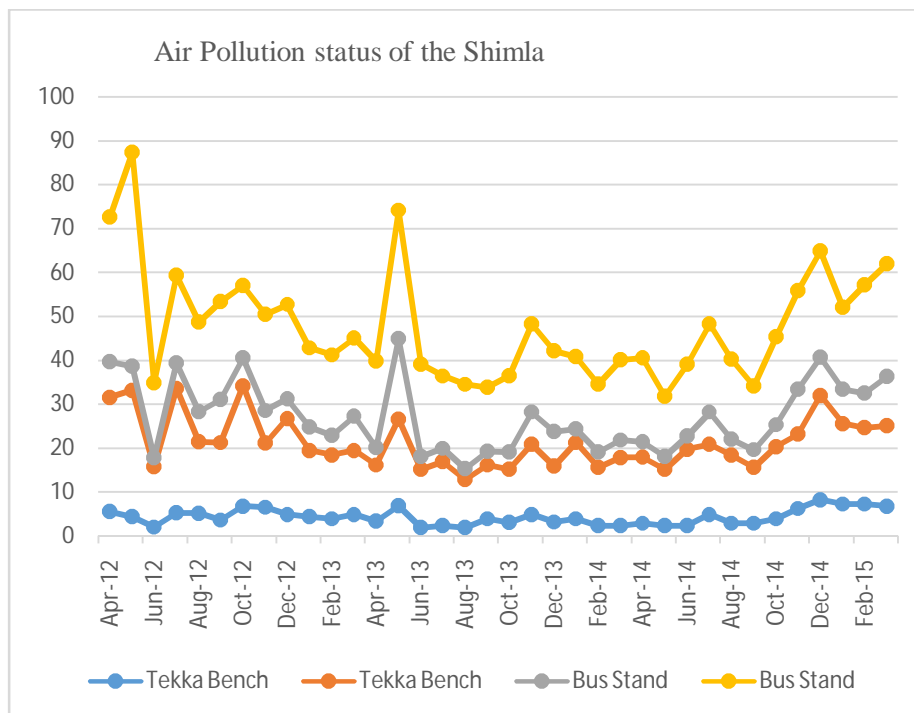


Fig. 1 Air Pollution Graph

From Fig 1, following observations are made:

- A significant control over the air pollution level can be seen after year 2012-2015.
- In comparison to the national quality standards, it can be concluded that still Shimla city, which is quite safe for health and pollution free.
- It is pertinent to mention that during peak tourist seasons, i.e. April –June and December – January every year, there is a rise in pollutants during this period.



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II. OBJECTIVES

The following are the objectives:

- (i) Set up experiment for Air Pollution Monitoring using WSN.
- (ii) Real time minute to minute updated status of the air pollution for the citizens.

III. WIRELESS SENSOR NETWORK

The details of the wireless sensor network are given below:

- A sensor network consists of multiple detection stations called sensor nodes, each of which is small, lightweight and portable. Every sensor node is equipped with transducer, microcomputer, transceiver and power source. The transducer generates electrical signals based on sensed physical effects and phenomena. The microcomputer processes and stores the sensor output and transmits the data to the coordinating station.
- These nodes can monitor, sense and collect information of different environment locations and various monitoring objects [3]. This is a solution based on the low-cost and low-power. Using a wireless sensor networks, information such presence of combustible gases (such as CO₂, CO, CH₄, O₂, NH₃, SH₂, NO₂, and many more) covered by the network can easily be collected, dealt with and analysed on real time basis.
- Sensor network communication framework for real time application: A wireless sensor network system includes sensor nodes, gateways, databases and a monitoring server. Sensor nodes are fitted with microcontroller of low processing capacity. Then data collected from sensors from the field is transmitted to its cluster head, through which it is further transmitted to the cloud and pollution monitoring station.

IV. METHODOLOGY

The methodology of this experimental set up is given below:

This paper is going to present an experimental set up of Wireless sensor network for the real time pollution monitoring with details of the coding.

- **Experimental Setup:** The Audrino platform was used for setup with energy efficient WSN. In this experiment, the Arduino board with firmware v.0.9 was used and windows compatible software IDE(Integrated Development Environment) 1.6.5 was installed in the system. Program was written for the different sensor such as Battery level of the sensor, nitrogen gases, Co₂ Gases, and connectivity with Wi-Fi access point. The following are the steps done for coding the program, in order to run the sensor board successfully, where snapshots are given for more clarity.
- **Step 1:** To run the IDE as administrator the first time it is started. Then accessed to folder %APPDATA%\Arduino15. The IDE core file Arduino.h contains the majority of the Arduino defines, constants, and macros, which in turn also includes several other files. Lily Arduino board program was selected. The IDE core file Arduino.h contains the majority of the Arduino defines, constants, and macros, which in turn also includes several other files. Lily Arduino board program was selected. Snap shot is given in figure 2.

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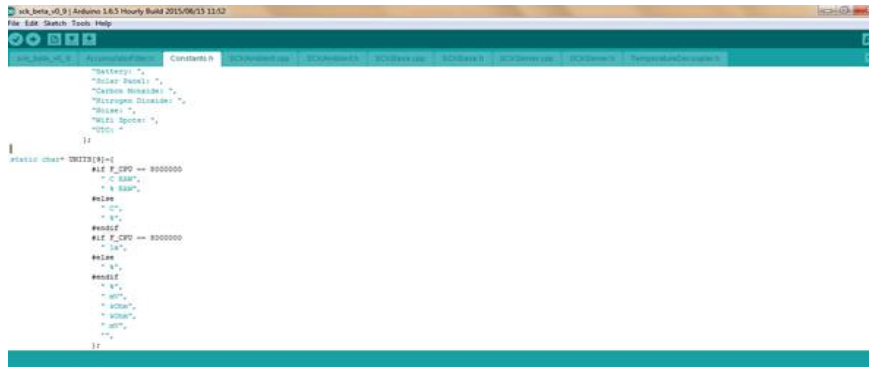


Figure 2. Snap Shot of the Program vs constants

Step 2. Lily Arduino Board selection for USB. Snap shot is given in figure 3

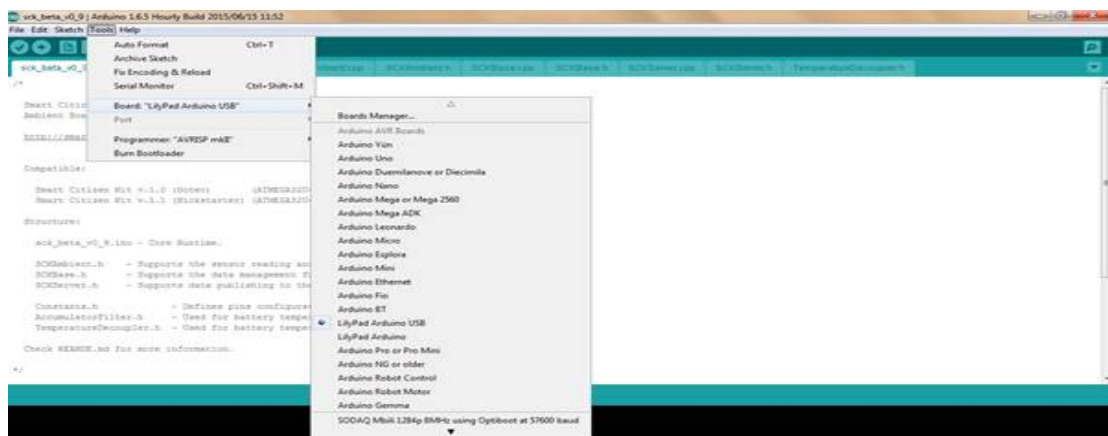


Figure 3: Snap Shot of the board selection.

Step 3. To verify the program with the board. Selection for the Wi-Fi access point in order to get connected to the cloud.ethingspeak [10] is given in figure 4.



Figure 4 Snap Shot of the program using Wi-Fi selection.

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Figure 8. Real time Nitrogen Dioxide

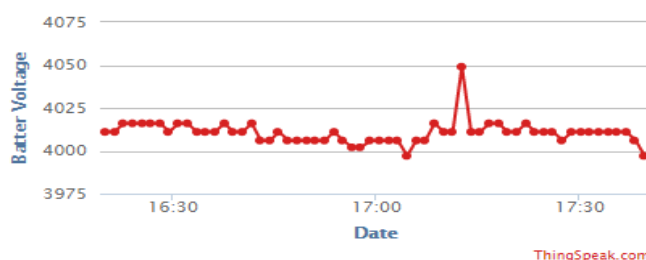


Figure 9: Real status of the battery

- Battery Status: WSN is totally dependent on the battery therefore to get the status of the battery is very important. This status could be seen online remotely which is depicted in figure 9.

VII. CONCLUSION

Using low cost wireless sensor network, it is possible to do the real time monitoring of air pollution. It becomes easy to visualise and analyse the data available online and remotely. Once the information is available online, then prevention steps could be taken in a time bound manner. This solution is very useful for the daily commuters or tourists visiting a particular place for taking decisions from time to time.

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