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Analysis of An Indoor Air Quality Antenna for Asthma Management in Children

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ABSTRACT

The extensive of diseases related with Indoor Air Quality (IAQ) usually referred to as Sick Building Syndrome (SBS) and Building Related Illness (BRI) has generated concern for technological approach in monitoring and analysis of the quality of air in confine environments. In line with "prevention is better than cure" mantra, such monitoring system is necessary for timely awareness of quality of surrounding air so as to take preventive action not only at the individual level, but also aid prompt diagnosis by the medical personnel. Motivated by the need for an affordable, simple and efficient indoor air quality device for general use at homes, offices and other related confine environment, a sensor node with capability for wireless sensor networking is presented in this study. The proposed device incorporates: sensors to measure major air quality indices: odor, carbon monoxide, dust, humidity, and temperature, LED indicators for prompt visual status alert, memory device (SD card) for off-line data access, and wireless capability for remote data transfer in applications such as web and mobile-apps interfacing. The performance of the system is evaluated in a laboratory scale indoor environment. The results show effectiveness of the system in capturing the air-quality status and providing timely information for proactive action.

Keywords : Indoor Air Quality, Sick Building Syndrome, Building Related Illness, wireless capability, mobile-apps.

I. INTRODUCTION

The alarming rate of indoor-air quality related diseases commonly referred to as Sick Building Syndrome (SBS) and Building Related Illness (BRI) has called for a pro-active solution proportionate to the advances in the related technological. SBS and BRI are related and can be defined as sickness and discomfort experience by occupants due to poor indoor air environment with no specific causes identify but related to amount of time spent inside. Symptoms such as headaches, sore throats, itchy eyes, breathing difficulties, lung cancer, asbestosis, mesothelioma, asthma, skin irritation and allergic reactions are among the reported health effect of poor air environment according to medical report and study [1-6]. According to the World Health Organization (WHO), 4.3 million people a year die from the exposure to household air pollution [4]. The problems are been compounded with the increasing amount of time people spend in a confine environment - either in home or in offices or in car, or malls or in school-, and the increasing potential of air pollution due to cooking using solid fuels, smoking in and around buildings, poor ventilation, dust, humidity and temperature. For instance, it has been reported that people spend a substantial proportion of their time in buildings [5]. In the arid region (MENA) most people spend 90% of their time indoors [1,2]. In response to these problems, research studies have been directed to (i) qualitative monitoring and analysis of indoor air quality, including guidelines on IAQ [4] and (ii) development of sensor node (monitoring system) for quantitative monitoring of the IAQ for several applications. For instance, assessment of indoor air quality pollutants in the offices and their potential negative effect in Dubai were carried out in [1] using both quantitative and qualitative techniques. In that study, the concentration levels of specific indoor air quality indicators (e.g. TVOC, Ozone, Carbon Monoxide, Carbon Dioxide, Relative Humidity and Temperature) was explored and analyzed in comparison to acceptable standard set by ASHRAE [7]. In [8], the indoor air parameters variation with respect to microclimate condition and impact of outdoor environment was investigated and reported with reference to large museum exhibition halls for a period of one year. The study showed the differences in indoor microclimate in air-conditioned rooms and non-air conditioned ones in the same building. In addition, external conditions were reported to have a significant impact on the indoor air parameters. On the other hand, at the system level, the pace of research work on monitoring systems for IAQ is driven by the dynamic rate of sensors and computing technologies advancement. Several studies have been reported in this direction [9-15]. A wireless monitoring system incorporating temperature, humidity, CO and CO2 sensors for HVAC control and IAQ monitoring is presented in [13]. An ATMega88 with a transceiver was adopted in the study for the implementation, sample performance results was presented to justify the success of the study. Sneha and Sandeep [10] presented an embedded system model for air quality monitoring incorporating a LCD display unit to help an allergic patient aware of its environment. No real-life data results presented in the study. Hybrid sensor system with both stationary and mobile sensors is reported in [15] for accurate tracking of air pollutant. Meanwhile, apart from the fact that no single system exists that addresses all the pollutants nor incorporates all the performance requirements for a given situation and environment, most of the IAQ devices are either expensive, thereby hindering affordability for general use, or lack simplified data presentation for a common end users. Hence, the current study proposes a wireless sensor node for IAQ monitoring with simplicity of indication (situation alert), affordability, easy of modification and maintenance, and yet provides opportunity of being fixed located at a place or used as a mobile hand-held device (i.e. mobility option). In addition, it is aimed to serve as a base for further research on the ongoing IAQ data monitoring and analysis, and IAQ wireless sensor networks applications suitable for the emerging Internet of Things (IoT).

The subsequent sections provide the essential of IAQ followed by the design and development of the proposed system, result, discussion and further study. The conclusion of the study is presented at the last section.

II. METHODOLOGY

The simplified block and components interfacing diagrams of the proposed IAQ Wireless Sensor Node (WSN) are shown in Fig. 1. The system comprises of five air parameter sensors - Carbon monoxide (CO), Methane (CH4), dust, humidity and temperature sensors-, microcontroller board for processing, LEDs display for status alert, micro SD card for data capturing, Wi-Fi for wireless interface capability and power supply. The three LEDs status alert are designated as follows: Green: indicates clean, Yellow: indicates moderate, and Red: indicates danger. This is to provide easy and prompt status information for the end users for timely proactive action

Apart from the cost and power consumption which are aimed to be low cost and low power, respectively, the choice of the sensors stated above is based on characteristic of the local environment, and common potential pollutant-generator indoor activities such as

- Tobacco smoking,
- Traditional charcoal-based air freshener
- Dust (penetration from outside dusty air, poorly maintained HVAC systems, etc.)
- Cooking gas leakage
- Sewage pipe leakage
- Ambient thermal influence

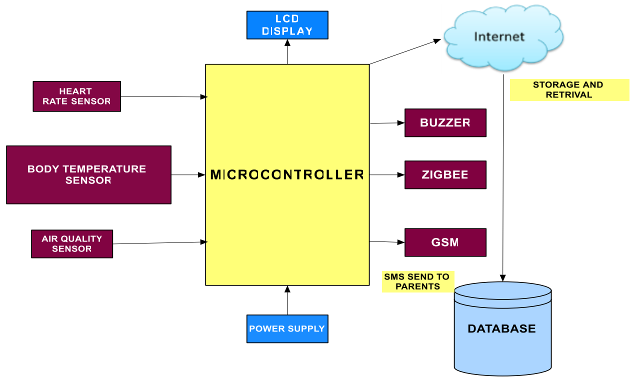

Fig 1 : Simplified Block and Components Interfacing Diagrams.

Several compounds constitute air pollutants once their concentration exceeded the Occupational

Exposure Level (OEL) specified by appropriate regulations/standards. The types and composition of the indoor air pollutants depends on ambient outside air condition and nature of the confined environment (be it residential, office, markets/malls, sport center etc.).

Essentially for a given indoor environment, the IAQ issues involved identification of potential pollutants, their sources, health concerns, standards/regulations in respect of their OEL, monitoring and preventive measures to minimize human exposure, and initiating corrective action when necessary. Among the major and common parameters in IAQ are Carbon monoxide, Carbon dioxide, Dust/particulates, Volatile Organic Compounds (VOCs), Formaldehyde, Methane, and temperature/Humidity for thermal comfort. Others are Benzene, Nitrogen dioxide, Sulfur dioxide, Radon etc. [16]. Table 1 gives the summary of the sources, effects and standards of the common IAQ parameters while the detailed can be obtained in the literatures [4, 16].

With respect to the management of IAQ issues (such as monitoring, prevention and control) the core requirement is air quality sampling and testing with the aid of appropriate instruments. Specific procedures have been proposed and reported in the sampling and measurements of different types of air contaminants. The common types of instrument are: direct-reading Colorimetric Tubes, Direct-reading Portable monitors, Air samplers, Smoke tube, Thermal anemometer, Direct-reading dust sampler, and microbial sampling [16]. It is noted that, (i) there is no single instrument to sample all the pollutants which necessitates the need for localized device for a given situation, (ii) some of the testing and sampling methods are only interpretable by IAQ professionals, thereby limits their direct adoption and benefits to the occupants (general users) and (iii) affordability in terms of cost still remains an obstacle towards widespread adoption of IAQ monitoring system for preventive maintenance and safety. These issues have led to dynamic research and development of different types of air testing/sampling instruments to meet the demands for timely and informative monitoring of the ambient indoor air condition in line with the state-of-the-art technology.

III. RESULTS, DISCUSSION AND FUTURE STUDY

The results of both web data transmission and real-time data monitoring show the successful implementation of the proposed IAQ-WSN. The web data interface of Fig. 1 provides the detail information on the status of the air parameters and working condition of the device. This is aimed at providing remote data access for occupants and health officers for timely preventive action. The results of Fig. 5 show the effectiveness of the node in monitoring the pollutant in real-time. All the pollutants data were captured almost at the same time, (around 6000seconds) based on the simultaneous injection of the materials in the enclosure. This provides a qualitative performance of the design and development of the proposed IAQ-WSN. Future study is expected to conduct quantitative analysis and benchmark the system performance with standard / industrial IAQ sensors. In addition, network of the nodes is to be developed with appropriate routing to cover large indoor environment or complete building.

IV. CONCLUSION

The design and development of a wireless sensor node for Indoor Air Quality monitoring system was presented in this project. The evaluation results of both web data transmission and real-time data monitoring show the successful implementation of the proposed IAQ-WSN. Future study is expected to conduct quantitative analysis and benchmark the system performance with standard / industrial IAQ sensors. In addition, network of the nodes is to be developed with appropriate routing to cover large indoor environment or complete building.

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