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Implementation of an Environmental Pollution Monitoring System for Industrial Facilities

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Abstract:

Air pollution is one of the most significant problems affecting the quality of life and the health of the rising urban population of industrial societies. A common industrial pollutant resulting from the incomplete burning of natural gas and any other material containing carbon is carbon monoxide and other hazardous substances. Real time environmental data monitoring has significant role in industries and also in everyday life. This study presents air pollution monitoring system using a gas sensor and a microcontroller. It also sends SMS to those who are likely overexposed to these pollutants. The system comprised of nodes/pairs of sensors and attendant microcontroller which are used to measure pollutant parameters at any particular point of interest. The data is read on a (Personal Computer) PC through a USB connection. The microcontroller-based system provides a tool for real time monitoring of carbon monoxide and Liquefied Petroleum Gases at any location deployed. This monitoring device can deliver real-time measurements of air quality. The system was deployed at an industrial location and it performed reliably.

Keywords: Microcontroller, pollution, sensors, carbon monoxide

1. Introduction

Air pollution has always been associated with civilizations and may be traced back to primordial times when man first lit the first fires. Environmental pollution was a direct effect of the industrial revolution, which saw the rise of massive factories and an increase in the consumption of massive amounts of coal and other fossil fuels [1]. Exposures to gaseous contaminants are commonly present in the workplaces. This can happen through inhalation, cutaneous absorption, or ingestion, inhalation of vapours, dusts, fumes, or gases. For some substances, absorption through the skin may also be a significant source of exposure. These substances or mixes may have immediate acute health impacts, or the effects on the body may take decades to manifest, lowering employee productivity.

Carbon monoxide is a typical industrial contaminant that results from the incomplete combustion of natural gas and other carbon-containing materials (CO). When carbon monoxide is inhaled, it displaces oxygen in the blood, denying oxygen to the heart, brain, and other essential organs. CO poisoning can happen suddenly and without warning, causing loss of consciousness and suffocation. CO poisoning symptoms include headache, fatigue, dizziness, sleepiness, or nausea, in addition to chest tightness [2]. During prolonged or high exposures, symptoms may worsen and include vomiting, confusion, and collapse [3]. Symptoms differ greatly from one person to the next. CO poisoning may strike those who are most vulnerable first: the elderly, those with lung or heart illness, those who live at high altitudes, and those who already have high CO blood levels, such as smokers. CO poisoning is also very dangerous for fetuses.

Environmental data monitoring in real time plays an important role in both industry and everyday life. Pollutant monitoring systems in the environment (air, soil, and water) have received a lot of attention in recent decades. These systems necessitate high-precision, selectivity, and sensitivity sensing elements. Data accuracy is particularly critical in these systems, as is the ability to store data for lengthy periods of time for analysis and decision-making. To aid in the monitoring of gaseous pollutant concentrations in the workplace, several environmental data monitoring systems have been created. However, most of these systems do not provide reliable data monitoring and subsequently cannot respond to sensitive emergency situations in industrial vicinities. In addition, data acquired by these systems are not being utilized for decision making especially in maintaining efficient employee health surveillance.

In this study, an environment pollutant monitoring system for industrial facilities using *arduino* microcontroller and digital sensors is implemented. The system measures environment data (gaseous pollutants) concentration; analyses the data collected over a period of time to obtain the exposure levels. It also compares periodic exposure levels with

employees' past medical history and periodically suggest those that might be at high risk, thereby enhances employees' health surveillance. The system will also triggers evacuating fans at exposures levels below those at which symptoms occur, while occupants still have time to take action to protect themselves.

2. Literature

Air pollution has been exacerbated by events that often occur when countries become more industrialized, such as expanding cities, more traffic, rapid economic development, industrialization, and higher levels of energy use. Numerous researchers have carried out elaborate study on environmental pollutant monitoring with different technologies but failed to utilize data acquired from this monitoring devices for organizational decision making.

In [7], an Air Pollution Measuring System with Mobile Sensor Arrays which measure Carbon Monoxide and Nitrogen Oxide was designed to develop an effective solution for pollution measuring using wireless sensor networks (WSN). The gas sensors are integrated with the ARM controller and location tracer GPS in User terminal. Other parameters like temperature are also sensed along with gas pollutant to enable data analysis through data aggregation techniques. Experimentation carried out using the developed air pollution measuring system under different physical conditions show that the system collects reliable source of fine-grain pollution data along with location of mobile vehicle. The system also collected pollution data using mobile hardware modules, transmits the data regularly using a GSM modem to a back-end server, and integrates the data to generate a pollution frame with geographical location and send to handheld devices of the user.

In addition, [8] designed and implemented a Micro Sensor Node for Air Pollutant Monitoring called APOLLO (Air Pollutants Monitoring System) sensor node, APOLLO was constructed with infrared based micro gas sensors. APOLLO provides air quality information by collecting independent sensing information from various air components and forwarding the collected data to the host system.

Also, [9] developed N-smarts which is a network suite mobile atmospheric real-time sensor. NSMARTS is a GPS-enabled cell phone-based or car mounted citywide environmental data acquisition system. Its sensor module consists of carbon dioxide, carbon monoxide, three-axis accelerometer, and temperature sensors.

In [10], an Out of the Box Environmental Monitoring device called Sensor Scope was designed. Sensor Scope is a large-scale wireless environmental monitoring system. Sensor Scope was developed to provide in-situ spatial and temporal observations across the landscape. Sensor Scope makes use of solar energy with extensive radio duty cycling to prevent power outages. Also, Environmental monitoring using sensors have been carried out in various countries and islands to measure particular parameters of interest as well as the development in air pollution/ industrial remote monitoring systems with applications in numerous regions, such as [11] who proposed a conceptual architecture for a versatile, flexible, cost efficient, high-speed instrument for monitoring air quality.

[13] examined the use of wireless sensors for monitoring carbon emissions in households for enhanced supervisory control and data acquisition, a new model which establishes interconnection between sensor nodes. This model is proposed and is used for transmitting data and information from remote locations with the aid of Wireless Sensor Networks via Satellite across international boundaries to researchers all over the world, and the corresponding emergency service points through structured messages.

Significant studies that motivated this present study and of which this work is largely based are the works carried out by [13] and [15] who developed a microcontroller-based data acquisition system for industrial air pollutant concentration measurement in industrial facilities in Nigeria using Ile-Ife Steel Company, Nigeria as a case study, and a remote monitoring system for estimation of carbon monoxide pollution in indoor environment respectively. The systems developed was able to measure CO pollutant concentration, trigger alarms, classify pollutant level, and display pollutant level on an LCD and save measured data in an external memory for future access. The research however, did not include what the acquired data could be used for, especially in organizational decision making as it concerns employees' health surveillance. Most of the studies reviewed in this section showed that most monitoring systems were cumbersome as a result of increased number of components used in the design. In most, pollution monitoring and measuring were not precise as there was no application written to aid data presentation and analysis. This research intends to solve these problems.

3. Materials and Methods

This study implemented an environmental data acquisition system for pollutant concentration measurement. The system comprised of nodes/pairs of sensors and attendant microcontroller which are used to measure pollutant parameters at any particular point of interest. The data is read on a (Personal Computer) PC through a USB connection. The data is subsequently stored in a database for future use. The Object-Oriented Analysis and Design (OOAD) methodology and notation symbols of the Unified Modeling Language (UML) were used in the analysis of the system.

Figure 1: Use Case Diagram of the Proposed System

4. Results

This section describes the implementation of the new system proposed in the previous section.

Figure 2: General View of the Application Software

The command buttons represent various functions performed by the system.

Figure 3: The 'Settings' Window Where the User Is Prompted to Select a Communication Port to Help Establish Connection between the PC and the Monitoring Hardware

Figure 4: The System Showing Data Obtained from the Monitoring Hardware on the Concentration of Carbon Monoxide in a Location

Figure 5: The System Showing Staff Registration form
(Each Employee Is Registered by the Admin under the Type of Gaseous Pollutant He/She Will Be Exposed to)

Prior to this, the admin determines the maximum exposure limit that could be allowed by each employee based on his/her health information. This is then entered into the system. This information helps the system to periodically send text messages to those employees that could possibly be overexposed to pollutants to see their doctor for a routine checkup.

Figure 6: Pollutant Data Monitoring Hardware

The hardware comprised of a gas sensor, *arduino* microcontroller and the evacuating fan. The hardware is connected to a workstation via a USB cable.

5. Conclusion

This study presents air pollution monitoring system using a gas sensor and a microcontroller. It also sends SMS to those who are likely overexposed to these pollutants. The system helps to create awareness of the quality of air that one breathes in an industrial facility. The microcontroller-based system provides a tool for real time monitoring of carbon monoxide and Liquefied Petroleum Gases at any location deployed. This monitoring device can deliver real-time measurements of air quality. The system was deployed at an industrial location and it performed reliably.

6. References

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