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AN EXPERT SYSTEM FOR ASSESSING SOLID FUEL POLLUTANTS FROM TRADITIONAL COOK-STOVES

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ABSTRACT

Most of the rural people in India use traditional stoves to cook for their families. They release carbon monoxide (CO) and other poisonous particulate matters to the air as a result of incomplete combustion of solid fuels. These pollutants are very harmful to the children, the women cooking near those stoves and more specifically the pregnant women causing serious health hazards to the inborn babies. An Indian woman on an average spends about 6-8 hours per day for this purpose. They spend 80 to 90% of their time at home cooking for their families and these primitive cook-stoves emit a significant amount of smoke, which fills all the rooms of a house. As the smoke contents varies significantly in various rooms, identifying the location of the person plays a vital role. An expert system that uses personal locators is an upcoming method brought about to specially educate the people, the need of improved stoves. These locators are designed in such a way that they determine the exact location of the person and also the duration of the women in that particular room. The stove temperature, location and exposure of the person are determined over a period of time indicating the changes in their locations and exposure levels each time in a specific place. Later obtained data are stored in the memory of the data logger. The stored data can be transmitted using wireless transmissions with the help of SIM 300 global system for mobile communication (GSM) modem to the server which is located at the area where further analysis is done.

Keywords: solid fuel pollutants, cook-stove, thermal energy, wireless communication.

1. INTRODUCTION

Most of the rural people in India use traditional stoves to cook for their families. They release carbon monoxide (CO) and other poisonous particulate matters to the air as a result of incomplete combustion of solid fuels. The pollutants released from the stove causes health impacts especially on children, the women cooking near those stoves and more specifically the pregnant women causing serious health hazards to the inborn babies [1-3]. Health impacts such as low birth weight for infants have proven to be global health concern affected by these pollutants [4,9]. An Indian woman on an average spends about 6-8 hours per day for this purpose. They spend 80 to 90% of their time at home cooking for their families and these primitive cook-stoves emit a significant amount of smoke, which fills all the rooms of a house [2,10]. As the smoke contents varies significantly in various rooms, identifying the location of the person plays a vital role. The main objectives of this system are to develop an expert system which locates the person in a particular room determining the duration of the person in that particular room.

Secondly the exposure level of the person to the solid fuel pollutants is taken under consideration. The typical traditional cook-stove generally called as Chula (Figure-1). The proposed paper describes a prototype which monitors these objectives and also transmits the collected data's wirelessly using Global System for Mobile (GSM) modem.

GSM effectively transmits the data from the locators placed in person's house to the servers placed in the control rooms. The effectiveness of this system is the real time monitoring of the data's through GSM technology. GSM module used here is the SIM 300 modem, which transmit and receive the data's. AT commands are used by the modem for the transmission.

Figure-1. Traditional cook-stove (Chula).

2. MATERIALS AND METHODS

The objectives of the proposed expert system are the determination of the location and the exposure levels of the pollutants to the person and thermal energy emitted by the cook-stove. The location of the person is determined using infra-red (IR) sensor and the exposure level is determined using a gas sensor. The proposed block diagram of the personal locator for assessing the solid fuel pollutants from the traditional cook-stove is shown in Figure-2. The operations of these sensors are processed with the interface of PIC microcontroller. The program is generated for the process using Embedded C and is being encoded into the controller. Also the interface of PIC with

the GSM is performed for wirelessly transmitting the data from the sensor. The data obtained from the sensors are monitored continuously as the person moves from one room to another. These data are sent through SMS for every in and out through a GSM receiver module. The receiver module is programmed for a particular Subscriber Identity Module (SIM) and the movement of the person between rooms is indicated. The data transmitted is displayed as a database using Visual Basic (VB) software.

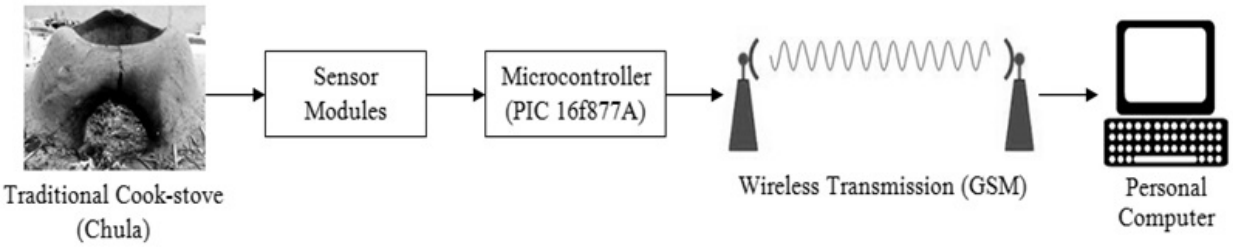

Figure-2. Block diagram of the proposed personal locator system for assessing solid fuel pollutants from traditional cook-stove.

a) Hardware used

Infra-red (IR) sensor: The IR sensor is an electronic device that emits or detects infra-red radiation in order to sense some aspects of its surrounding. It can detect heat as well as motion of an object. Hence it is sometimes called as the motion detector. The range of IR radiation varies from 0.75micrometer to 1000micrometers. The human body generates heat an infra-red signature as heat which is detected by the IR sensor and thus it detects the motion of a person. The IR sensor and the gas sensor are connected separately in the I/O pins of the PIC microcontroller. The IR sensor is divided into 2 parts: IR transmitter and IR receiver. The IR transmitter is designed in such a way that it is worn by the person all over the day. The compact design of the transmitter is an important agenda as people nowadays are concerned about the looks and design of products. The compact design of the transmitter will comfort the person in wearing it all long the monitoring phase. The IR receiver is mounted on the doorstep of every room. Each time the person with the tag passes through the receiver, the receiver will detect the signals from the transmitter and locate the person in the room, the receiver is placed. The gas sensor is separately placed in each rooms of the person. And it continuously monitors the gas level, i.e., the exposure level of gases in the particular room. The gas level is displayed each time on the LCD screen. The outputs from the sensors are obtained from the microcontroller. The GSM modem and LCD are connected to microcontroller. The output can be monitored directly which is simultaneously displayed in the LCD and message to the mobile by using GSM technique.

Gas sensor (MQ-2): The MQ-2 gas sensor is very sensitive to gases like carbon monoxide, methane, alcohol and smoke. The sensor can operate at temperature of -20 to +50C and consumes less than 150mA of current.

Temperature sensors: LM35 is a sensor is used to sense the temperature. It is a precision integrated-circuit centigrade temperature sensor whose output voltage is linearly proportional to the Celsius (Centigrade) temperature. The temperature received in the output of LM35 does not need any further calibration or any other functions and also it draws only 60 micro amps from its supply [5,6]. The LM35 thus has an advantage over linear temperature sensors calibrated in degree Kelvin, as the user is not required to subtract a large constant voltage from its output to obtain convenient Centigrade scaling. For each degree Celsius change in temperature, the sensor output changes by 10mV. The sensor can measure temperature in the range of 0 to 100°C, i.e., the output of the sensor varies from 0 to 1000 mV. The LM35 operates over the temperature range of -55° to +150°C. The output voltage varies by 10mV in response to every °C rise/fall in ambient temperature, i.e., its scale factor is 0.01V/degree C.

Resistance temperature detectors (RTD) accurately sense temperature with an excellent degree of accuracy. The RTD is composed of certain metallic elements whose change in resistance is a function of temperature. Platinum wire wound detectors (PT-100) comprise a pure platinum wire wound into a miniature spiral and located within axial holes in a high purity alumina rod. A PT-100 is a precision platinum resistor that exhibits 100Ω at 0ºC. It has a positive temperature co-efficient so as the temperature rises, so does the resistance.

Microcontroller: The microcontroller used in the proposed system is peripheral interface controller (PIC) 16F877A. The PIC16F887 is one of the latest products from *Microchip*. It features all the components which modern microcontrollers normally have. For its low price, wide range of application, high quality and easy availability, it is an ideal solution in applications such as: the control of different processes in industry, machine control devices, measurement of different values.

The PIC 16F877A is a 40-pin 8-Bit Microcontroller with 8k×14-bit flash program memory, 368 bytes of RAM and many other extra peripherals like Analog to Digital Converter (ADC), universal

synchronous asynchronous receiver transmitter, master synchronous serial port, timers, compare capture and pulse-width modulation modules, and analogue comparators. Its internal circuitry reduces the need for external components, thus reducing the cost and power consumption and enhancing the system reliability. It is based on the reduced instruction set computer (RISC) architecture.

Global System for Mobile (GSM): This second generation wireless standard was developed as an improvement over first generation wireless standard. Global system for mobile communication is a globally accepted standard for digital cellular communication [6,7].The most popular pan-European standard is based on time division multiple access (TDMA) technology. Fig. 3 shows the GSM module that uses three frequency bands: 900 MHz, 1800 MHz and 1900 MHz Dual –band phones operate on two out of these frequencies, while tri-band phones operate on all three frequencies. The advantage of using GSM technology is that it has a wide international coverage. The use of SIM card makes it easy to switch between different handsets and allows for the quick and easy import of data's such as text messages, contacts etc.

Figure-3. Global system for mobile communication module.

SIM300: SIM300 is a Tri-band GSM/GPRS engine that works on frequencies EGSM 900 MHz, DCS 1800 MHz and PCS1900 MHz. SIM300 provides GPRS multi-slot class 10 capabilities and support the GPRS coding schemes CS-1, CS-2, CS-3 and CS-4. With a tiny configuration of 40mm x 33mm x 2.85 mm, SIM300 can fit almost all the space requirement in your application, such as Smart phone, PDA phone and other mobile device [6]. SIM300 provide RF antenna interface with two alternatives: antenna connector and antenna pad. The antenna connector is MURATA MM9329-2700. Customer's antenna can be soldered to the antenna pad. The SIM300 is designed with power saving technique, the current consumption to as low as 2.5mA in SLEEP mode [7,8]. The SIM300 is integrated with the TCP/IP protocol, Extended TCP/IP AT commands are developed for customers to use the TCP/IP protocol easily, which is very useful for those data transfer applications. SIM 300 provides physical interface like a keypad, SPI LCD interface and two serial ports.

b) Software used

MPLAB IDE program: The program is written in Embedded C in MPLAB IDE.MPLAB. Integrated development environment (IDE) is an integrated toolset for the development of embedded application employing Microchip's PIC microcontroller [5]. MPLAB IDE is a very powerful software development tool for Microchip products (microcontrollers). It consists of tools like text editor, cross-assembler, cross-compiler and simulator. Hitech C cross compiler is meant for Microchip. The compiler tool is the ISIS Proteus software used to convert C Language to HEX File. The HEX file is programmed into the PIC microcontroller using pic kit2.The version of MPLAB IDE Tools used isV8.70.

The software performs the following operations in an infinite loop:

- Initiate analogue-to-digital conversion and obtain the result
- Enable the control registers (ADCON0 & ADCON1)
- Calculate the equivalent voltage value from the ADC result
- Interface the SIM300 with the microcontroller through the serial port pins RC6 and RC7
- Initialize the Transmitter and Receiver status and control register (TXSTA& RCSTA)
- Display the measure and values on the LCD

The Hi-tech C cross-compiler provides floating-point library support that is required for doing the above calculations.

AT Commands: AT stands for "attention"

- AT+CSMS - Select short message service
- AT+CMGF - Set short message service mode (1 for text Mode, 0 for PDU mode)
- AT+CMGS - Sent short message
- AT+CSCA - Short message service number

Figure-4. Proposed prototype of the personal locator system and pollutant exposure level monitoring system.

The IR in and out determines the location of the person and also the duration of the person in that particular room. When the IR in senses a motion, it detects the location of a person, say R1, R2. When the IR out is cut, the duration of the person in a particular room is determined. Once, the activity of the In and out of the IR sensor is completed, a message is sent to the GSM transmitter through the PIC microcontroller. A GSM is also placed on the receiver side. The messages are transmitted to the receiver GSM through the transmitter GSM as in case of mobile phones sending and receiving the messaged through GSM reception. These messages are displayed on the output layout created using the Visual basic software and they are also updated in the database created using Microsoft Access. Simultaneously the gas content of the room is measured by the MQ-2. The MQ-2 is designed in such a way that it detects the contents of carbon, particulate matter and smoke in a particular region. The programs designed for these processes are done using embedded c language. The proposed prototype and schematic diagram of the personal locator system and solid fuel pollutant exposure level monitoring system are shown in Figure-4 and Figure-5.

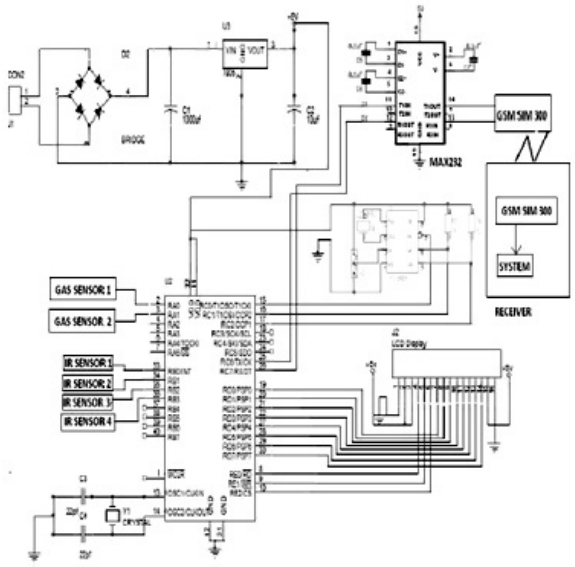

Figure-5. Schematic diagram of the personal locator system and pollutant exposure level monitoring system.

3. RESULTS AND DISCUSSIONS

The proposed expert system can precisely measure the two required parameters of the person facilitating real time monitoring database of the system using the visual basic software. The proposed personal locator assessment system was built to determine certain parameters: location of the person, the duration of the person staying in the room and the exposure level to the solid fuel pollutant in the room. The prototype proved to work efficiently determining the required parameters from various rooms. The system showed outputs about the presence of the person in a particular room. It also determined the duration of the person in that particular room storing in the database the above obtained information. The exposure levels were also determined using the gas sensor.

The system can be controlled and monitored via SMS from anywhere that covered by GSM service. In our project we have just proposed the prototype for monitoring thermal energy from traditional stove. This technology promises to be of great use to groups interested in the standardization of methods to quantify carbon emission reductions and other changes due to improved stoves, for evaluating dissemination strategies and for behavioral research. The IR sensor, temperature sensor and gas sensor are connected to PIC microcontroller and varying temperatures of the stove is sent to GSM modem this is simultaneously displayed in LCD and also send a message. The temperature database received from the proposed data-logger system shows the periodic temperature readings of the traditional cook-stove transmitted by the GSM modem (Figure-6).

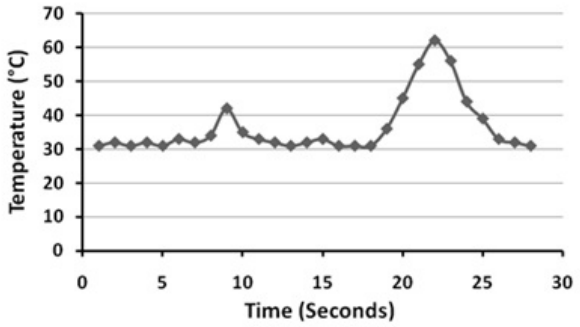

Figure-6. Temperature of traditional cook-stove over periodic intervals.

The data base is created using Microsoft access. Access stores data in its own format based on the Access Jet Database Engine. It can also be imported or linked directly to data stored in other Access databases, Excel, SharePoint lists, Text, XML, Outlook, HTML, dbase, Paradox, Lotus 1-2-3, or any ODBC-compliant data container, including Microsoft SQL server, Oracle, MySQL and PostgreSQL. Access is supported by VB for Applications, an object-oriented programming language that can reference a variety of objects including (Data Access Objects (DAO), ActiveX Data Objects, and many other ActiveX components.

A statistical analysis is carried out using the temperature values and stove usage pattern. Statistical analysis refers to the collection, examination, manipulation and interpretation of quantitative data in order to discover the underlying causes, patterns, relationship and trends among the sensed parameters. The recorded temperature data against the stove usage over a period is shown in the Figure-7.

The piloted data perceived shows that the person spent most of the time in that particular room. This when subjected to a real time system will tell us if the person

was in the kitchen most of the time or in the other rooms. The Figure-7 shows the calculated duration of the person stay in the kitchen, just to take an average of 24 hours of living and cooking patterns [8]. The Figure-7 also shows the exposure level of smoke in that particular room, which can approximately tell us that the person might get exposed to these levels of smokes causing them various health hazards [8].

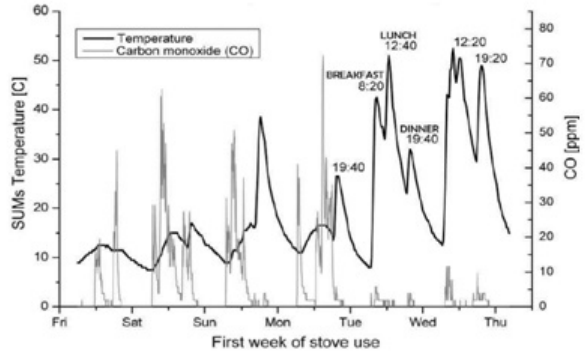

Figure-7. Temperature and CO gas exposure level recorded against stove usage period [8].

This study implementation comes to the conclusion that the temperature of the stove can be monitored using LM35 and RTD (temperature sensors); personal locator; CO exposure level can be monitored and can be send as SMS to mobile successfully. A special database can be created using VB software which gives the full description about the cooking profile of the people.

The data-logger cum monitoring setup gives precise and unbiased measurements of stove usage. It also facilitates the establishment of live database of cook-stove usage using VB software. The system can be controlled and monitored via Short Message Service (SMS) from anywhere that covered by GSM service. In this paper we have just introduced the proto type data-logger [4] for monitoring thermal energy from traditional cook-stove. This technology promises to be of great use to groups interested in the standardization of methods to quantify carbon emission reductions and other changes due to improved stoves, for evaluating dissemination strategies and for behavioral research. This prototype can be developed into a monitoring device which can also be used for environmental research purpose especially in the area of monitoring indoor air pollutants from traditional cook-stoves.

The expert system has the following merits such as wireless transmission of data, usage of less man-power and less expense. The de-merits of the proposed expert system are accumulation of large volume of data, signaling problem associated with SIM300 modem as a result of network congestion and weather condition. The future scope of the proposed system is that it can be developed into a monitoring device which can be used for environmental research purpose especially in the area of monitoring indoor air pollutants from traditional stoves.

4. CONCLUSIONS

The location, duration and the exposure levels of the person is accurately determined by the expert system. The results were matched with that of the standardized values which proved the proposed system to be effective means of determining the facts about the traditional cook-stoves. And we wish to conclude from all the above that this system will work to be a promising way of determining the levels of exposure of the solid fuel pollutants to the mother and their children in various ways causing serious health hazards which kill them at the end of the day.

The temperature profile of the cook-stove is also obtained thereby we can obtain accurate data about the stove usage pattern by the people. The paper concludes that the data collected using the proposed protocol would be highly useful for research people who are engaged in analyzing the impacts of traditional stove usage. This system can also effectively replace the questionnaire and survey system which basically depend on the householder's memory and are not always accurate enough. The extension of this study would help the Government to educate the people about the health impacts caused due to indoor air pollution and help them to switch over to use improved cook-stoves.

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REFERENCES

[1] D. Behera and G. Aggarwal. 2010. "Domestic cooking fuel exposure and tuberculosis in Indian women", The Indian Journal of Chest Diseases & Allied Sciences, Vol. 52, No. 8, pp.139 – 143.

[2] D. Behera, T. Chakrabarti and K.L. Khanduja. 2001. "Effect of exposure to domestic cooking fuels on bronchial asthma", The Indian Journal of Chest Diseases & Allied Sciences, Vol.43, No. 113, pp. 27 – 31.

[3] P. A. Mahesh, B.S. Jayaraj, A. K. Prabhakar, S.K. Chaya and R. Vijaysimha. 2013. "Identification of a threshold for biomass exposure index for chronic bronchitis in rural women of Mysore district", Indian J Med Res, Vol. 137, No. 1, pp. 87 – 94.

[4] M. Mohammadyan. 2012. "Personal exposure and indoor home particulate matter: A review", IJEE An Official Peer Reviewed Journal of Babol Noshirvani University of Technology, Iranica Journal of Energy & Environment, Vol. 3. No. 3, pp. 246 – 254.

[5] R. Mukhopadhyay, S. Sambandam, A. Pillarisetti, D. Jack, K. Mukhopadhyay, K. Balakrishnan, M. Vaswani, M.N. Bates, P.L. Kinney, N. Arora and K.R. Smith. 2012. "Cooking practices, air quality, and the acceptability of advanced cookstoves in Haryana, India: an exploratory study to inform large-scale interventions", Glob Health Action, Vol. 5, No. 19016, pp. 1 – 13.

[6] T. Murugan, Azha. Periasamy and S. Muruganand. 2012. "Embedded based industrial temperature monitoring systems using GSM", International Journal of Computer Applications, Vol. 58, No. 19, pp. 1 – 11.

[7] V. Pandya and D. Shukla. 2012. "GSM modem based data acquisition system", International Journal of Computational Engineering Research, Vol. 2, No. 5, pp. 1662 – 1667.

[8] I. Ruiz-Mercado, N.L. Lam, E. Canuz, G. Davila and K.R. Smith. 2012. "Low-cost temperature loggers as stove use monitors (SUMs)", Journal of Environmental Monitoring, Vol. 13, pp. 16 – 18.

[9] E. Boy, N. Bruce and H. Delgado. 2002. "Birth eight and exposure to kitchen wood, smoke during pregnancy in rural Guatemala", Children's Health Article, Environmental Health Perspectives, Vol. 110, No. 1, pp. 109 – 114.

[10] N. MacCarty, D. Still, D. Ogle and T. Drouin. 2008. "Assessing cook stove performance: field and lab studies of three rocket stoves comparing the open fire and traditional stoves in Tamilnadu, India on measure of time to cook, fuel use, total emissions, and indoor air pollution", Aprovecho Research Center, pp. 1 – 18.