Remote Monitoring and Estimation of Carbon Monoxide Pollution in Indoor Environment using Wireless Sensor Network via Satellite.

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ABSTRACT

Sub-Saharan Africa is massively hit by the effects arising from the excessive cutting down of trees which serve as fuel for cooking in most local communities. This paper examines the use of wireless sensors for monitoring carbon emissions in households for enhanced supervisory control and data acquisition (SCADA), a new model which establishes interconnection between sensor nodes. This model is proposed and is used for transmitting data and information from a 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.

(Keywords: indoor air pollution, data acquisition, mathematical model, CO emission)

INTRODUCTION

Climate change is one of the most important factors affecting the quality of life and the activity our growing population. In Sub-Saharan Africa, most areas have some networks of monitoring carbon credits. This is necessary for the continuous measurements of the amount of carbon in the atmosphere.

This work seeks to contribute to the estimation of the amount of carbon which is discharged into the air from household cooking using fuel wood (firewood) with particular reference to poor rural dwellers in Sub-Saharan Africa. Besides the health effects, the region is presently experiencing rapid desert encroachment and is gradually losing its green habitats leaving the populace vulnerable to the various factors arising from the absence of green vegetation [1].

This paper also seek to set up a system that can collect data, estimate values, and adopt the use of wireless sensors for monitoring carbon emission from household cooking for enhanced supervisory control and data acquisition (SCADA) systems where a new model establishing interconnection between sensor nodes is proposed and optimal inter-sensor distance with respect to their signal levels are investigated. The wireless communication systems are used for exchanging messages between technicians and the corresponding emergency service points through structured messages [1].

Monitoring and control has made vast advances in various applications for over the last decade, helping technological improvements in sensing and computation with breakthroughs in the underlying principles and mathematics.

Currently, embedded processors, sensors, and networking hardware are becoming increasingly complex , intelligent, and autonomous systems for monitoring and control. In industrial network control systems for example, strong interest in wireless solutions is driving the development of this technology as a potential replacement for current generation of wired industrial network.

A carbon monoxide detector, or CO detector, is a device that detects the presence of the carbon monoxide (CO) gas in order to prevent carbon monoxide poisoning. CO is a colorless and odorless compound produced by incomplete combustion. It is often referred to as the "silent killer" because it is virtually undetectable without using detection technology [1]. Elevated levels of

CO can be dangerous to humans depending on the amount present and length of exposure.

Smaller concentrations can be harmful over longer periods of time while increasing concentrations require diminishing exposure times to be harmful.

CO EMISSIONS

Wood is mainly just carbon, hydrogen, and oxygen: $[CH_2O]_x$

Combustion:

$CH_2O + O_2 \rightarrow CO_2 + H_2O + \text{heat}$

When inhaled, CO binds with hemoglobin in the blood (displacing O_2), forming carboxyhemoglobin [COHb] as seen in Figure 1 and 2.

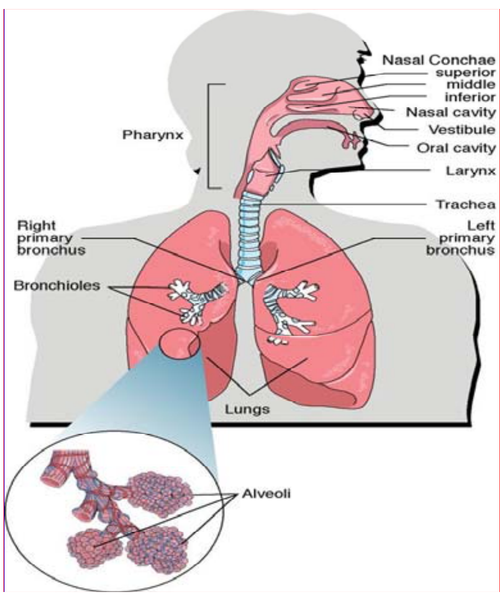

Figure 1: Uptake in the Human Body.

Carbon monoxide does not diffuse into the upper airway as other pulmonary irritants. CO penetrates into the alveolar region where it can be absorbed into the blood stream.

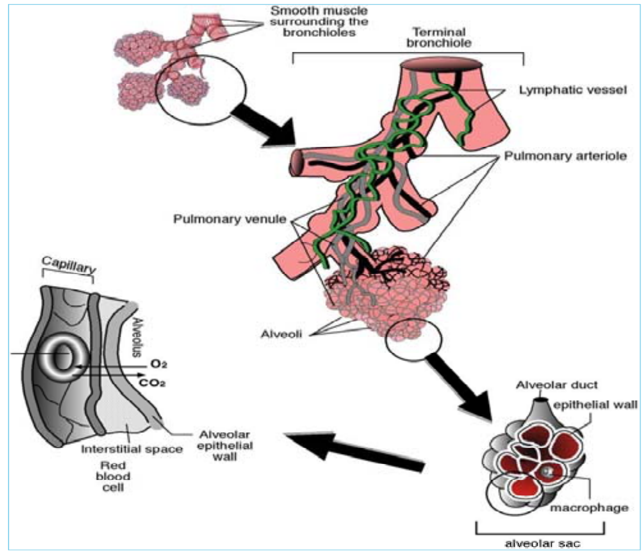

Figure 2: Diffusion Process.

Figure 3 shows a breakdown of impacts from air pollution.

Figures 4 and 5 show a typical cooking situation in Sub-Saharan Africa.

Figure 6 illustrates the size distributions of several sources of particulate matter (PM) emissions.

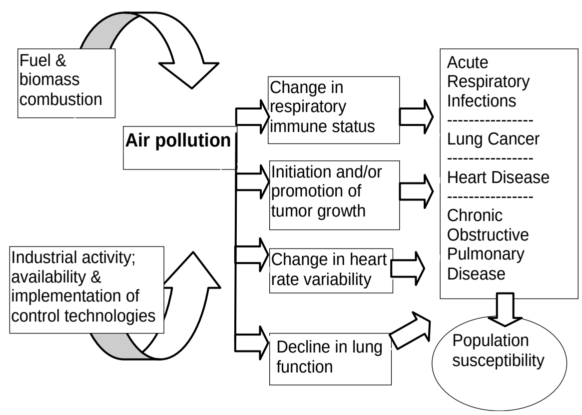

Figure 3: Impacts from Air Pollution.

Figure 4: Open Fire Cooking by Firewood with Significant amounts of CO Discharge.

Figure 5: Open Fire Cooking Practices as Typically Employed in Rural Sub-Saharan Africa using Firewood as a Fuel.

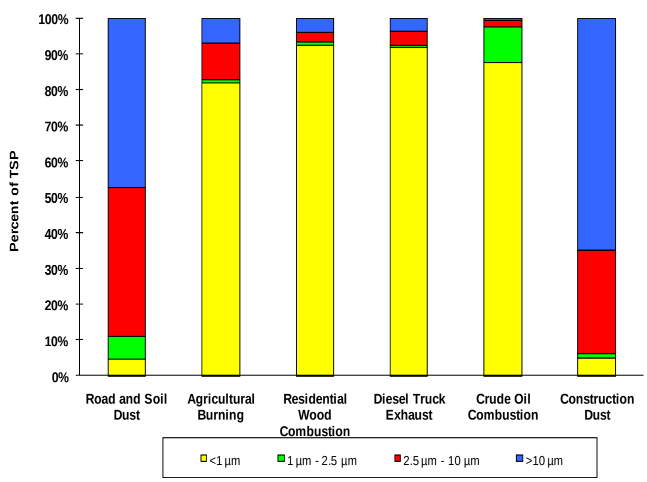

Figure 6: Size Distributions of Several PM Source Emissions.

ELECTRO-CHEMICAL MONITORS

Electrochemical Gas Sensors: are gas detectors that measure the concentration of a target gas by oxidizing or reducing the target gas at an electrode and measuring the resulting current.

CONSTRUCTION OF SENSOR

The sensors contain two or three electrodes, occasionally four, in contact with an electrolyte. The electrodes are typically fabricated by fixing a high surface area precious metal to the porous hydrophobic membrane. The working electrode contacts both the electrolyte and the ambient air to be monitored usually via a porous membrane.

The electrolyte most commonly used is a mineral acid, but organic electrolytes are also used for some sensors. The electrodes and housing are usually in a plastic housing which contains a gas entry hole for the gas and electrical contacts.

THEORY OF OPERATION

The gas diffuses into the sensor, through the back of the porous membrane to the working electrode where it is oxidized or reduced. This electrochemical reaction results in an electric current that passes through the external circuit.

In addition to measuring, amplifying and performing other signal processing functions, the external circuit maintains the voltage across the sensor between the working and counter electrodes for a two electrode sensor or between the working and reference electrodes for a three electrode cell. At the counter electrode an equal and opposite reaction occurs, such that if the working electrode is an oxidation, then the counter electrode is a reduction. As an example we outline a sensor scenario below (Figure 7):

- Two electrodes are immersed in a highly conductive electrolyte solution (sulfuric acid)
- CO, in the present of O_2, is converted to CO_2
- Voltage drop across a resistor is measured using Ohm's law (V=IR)
- The voltage is directly related to CO concentration

The conversion of an electrical signal is demonstrated in Figures 8 - 10.

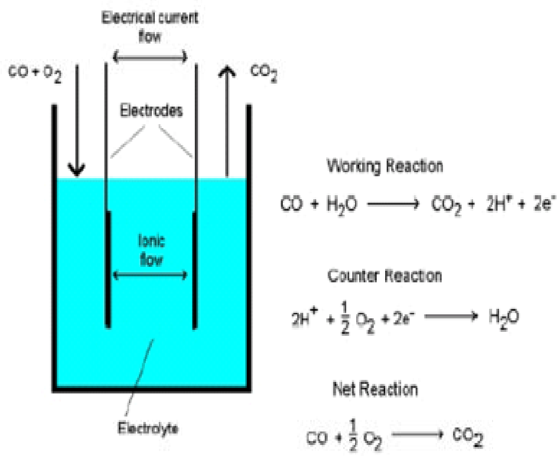

Figure 7: Sensing Carbon Monoxide.

A wireless sensor network (WSN) consists of spatially distributed autonomous sensors to cooperatively monitor pollutants like Carbon monoxide.[12] Wireless Sensor Node's are set up at different cooking outlets , signal is been transmitted In addition to one or more sensors, each node in a sensor network is typically equipped with a radio transceiver or other wireless communications device, a small microcontroller, and an energy source, usually a battery.

WIRELESS SENSOR NETWORK

A wireless sensor network (WSN) consists of spatially distributed autonomous sensors to cooperatively monitoring pollutants like carbon monoxide [12]. Wireless Sensor Node's are set up at different cooking outlets where the signal is transmitted. In addition to one or more sensors, each node in a sensor network is typically equipped with a radio transceiver or other wireless communications device, a small microcontroller, and an energy source, usually a battery.

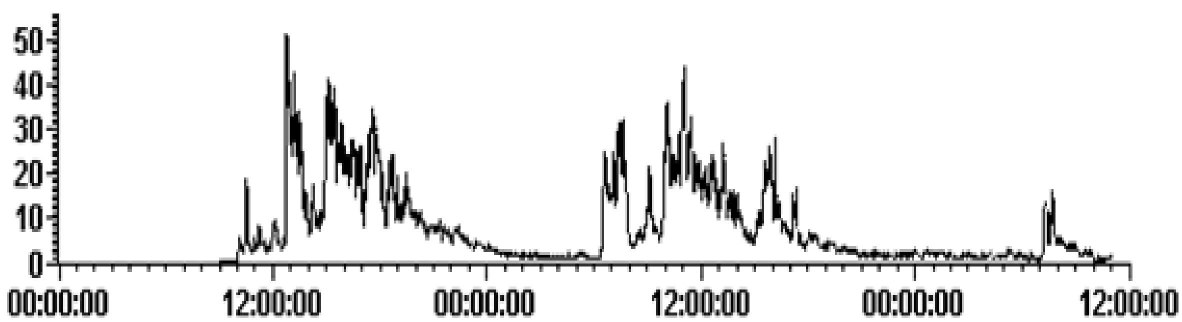

Figure 8: Conversion of an Electrical Signal.

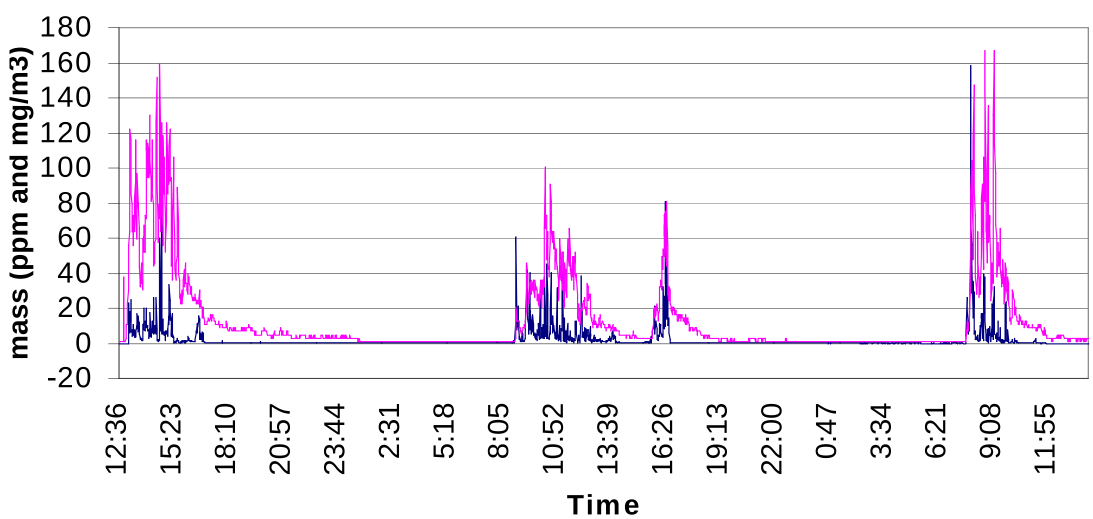

Figure 9: Graph Showing Period of CO Emission.

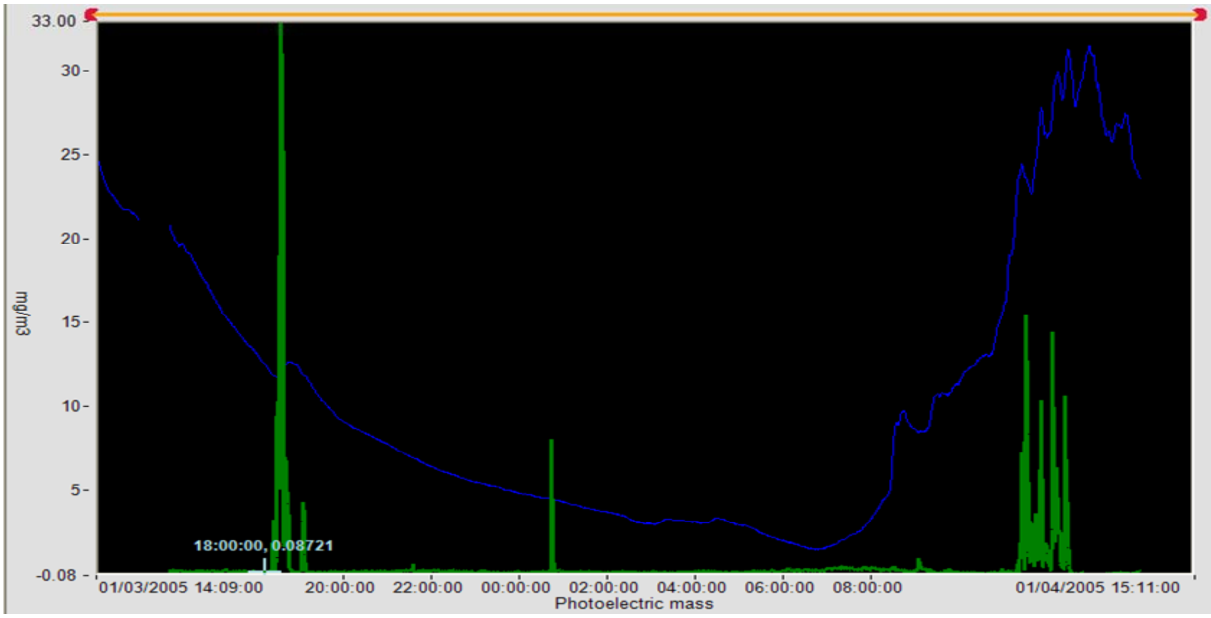

Figure 10: CO Emission Graph Simulation.

Since modern microcontrollers are so cheap , it is very common to implement monitoring systems, including feedback loops, with computers, often in an embedded system. The feedback controls are simulated by having the computer make periodic measurements and then calculating from this stream of measurements (digital signal processing).

WSNs is a complex network, which is composed of many sensor nodes. It is difficult to describe the sensor node using existing models for the different application environments. In this paper, we propose a neural cell model to depict the senor nodes. The given model is shown in Figure 11.

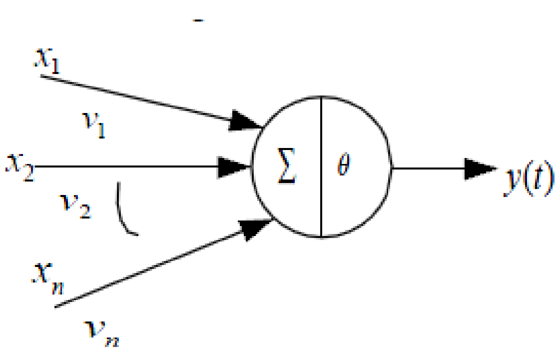

Figure 11: Sensor Node Model for Collective Data Collection,

DATA TRANSMISSION AND RECEIVING PROCESS

The sensor node can measure data from any physical system and send it, usually via radio transmitter, to a command center or sink node, either directly or through a number of communication and data concentration devices (or gateways).

The decrease in the size and cost of sensors devices has increased the interest in using sets of disposable and unattended sensors. This has led to intensive research addressing with the potential of collaboration among sensors in data collecting, processing and management of the sensing activities, within the last few years.

Where x1, x2 ... xn can be seen as data collected by sensor nodes, y (t) is the output after the data fusion of sensor nodes, v1, v2 ... vn is the weight, denotes the threshold. The relationship between output and input can be expressed as formula (1).

$$Y(t) = f\left[\sum_{i=1}^{n}[v_i x(t) - \theta]\right] \quad \textbf{(1)}$$

In addition to one or more sensors, each node in a sensor network is typically equipped with a radio transceiver or other wireless communications, all the sensors are networked and summed up via a gateway in Figure 12; an elaborate model is shown in Figure 13. Here the process of data collection is sensed, conditioned, and later processed with a signal method used for re-conditioning. The signals are then modulated and later transmitted beyond boundaries via satellite signal.

An interactive interface software is setup to the wireless communication systems and used for exchanging messages between the supervisor and the corresponding emergency service points through structured messages. The test results obtained from a field trial as shown in Database Interface in Figures 14 and 15.

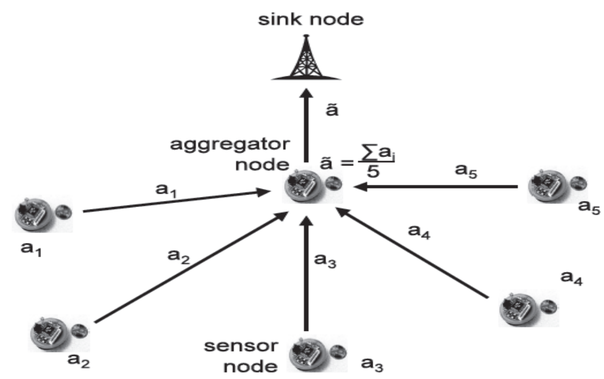

Figure 12: Wireless Sensor Node Model.

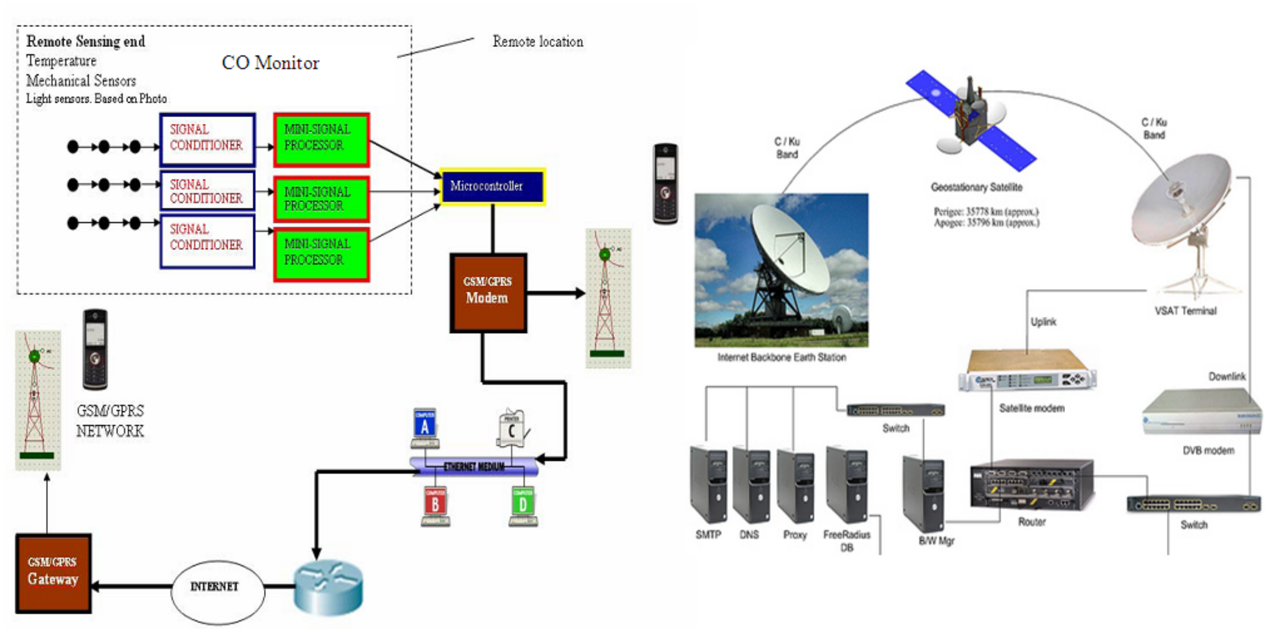

Figure 13: Complete Data Transmission Model.

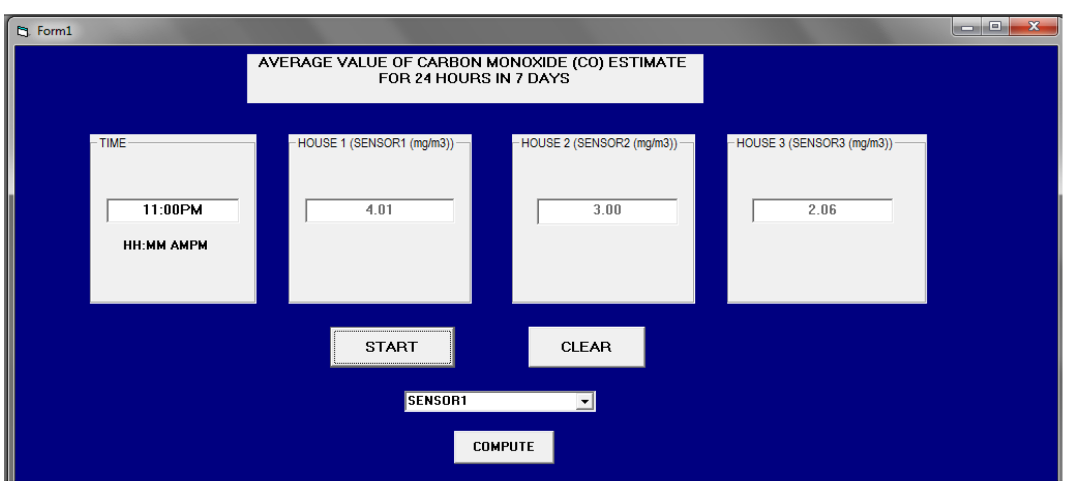

Figure 14: Data Capturing Interface.

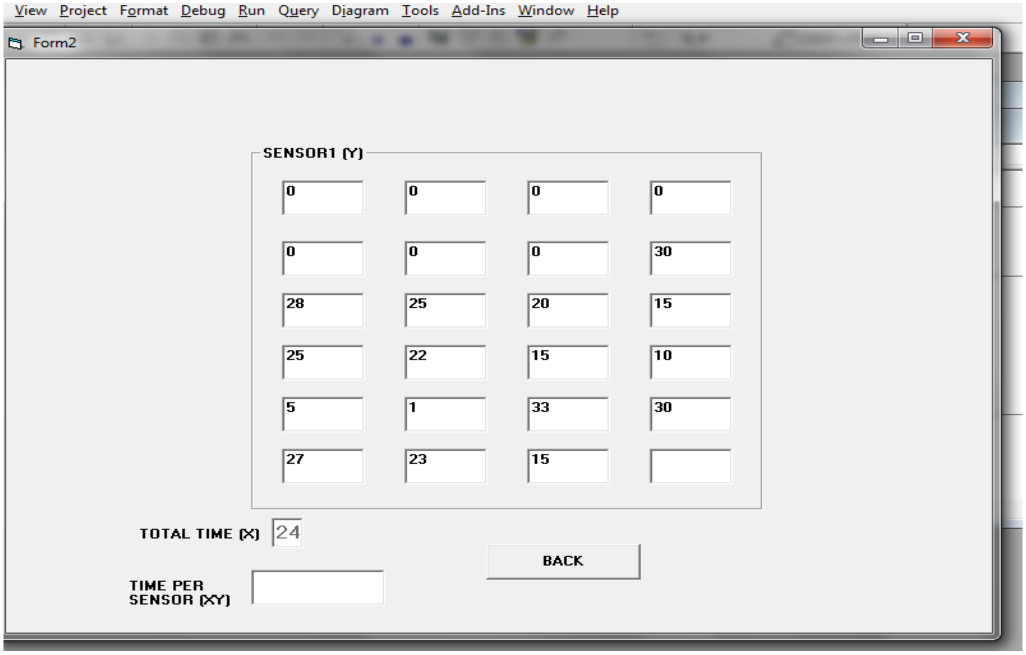

Figure 15: Data Interface Showing Carbon Credits.

CONCLUSION

This work realizes the method of estimating and measuring the amount of carbon credit as discharge via carbon monoxide form local cooking and household cooking. One major problem has been quantization of the problem without a process for estimating it. This process will automatically generate data for the carbon supervisor at any point in time for supervisory control and data acquisition.

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