WSN Based Industrial Pollution Monitoring System using Arduino

Mr.S. Senthamilarasu[1], M. Arun Prasath[2], M. Bala Pandian[3], S. Manoj Kumar[4]
[1]Asst. Professor, Dept of ECE
[2, 3, 4] Dept of ECE
[1, 2, 3, 4] P.A. College of Engineering and Technology, Pollachi.

Abstract- *This paper presents a WSN (Wireless Sensor Networks) based industrial pollution monitoring system by using Arduino in which the air quality, temperature, humidity, pH level of water content, level of carbon monoxide gas, Dust particles can be monitored. In the implementation of WSN based system, different sensors such as Temperature and humidity sensor, Dust sensor, Air Quality gas sensor, Carbon Monoxide sensor, pH sensor, are used to monitor different parameters around the industrial area. Air Quality Monitoring (AQM) is carried out to assess the extent of pollution, ensure compliance and provide data for air quality monitoring. Wireless Sensor Network (WSN) that can be easily deployed in highly polluted areas such as manufacturing industries of India to monitor air quality index.*

Keywords- Wireless Sensor Networks; Air Quality System; sensors; Arduino UNO R3.

I. INTRODUCTION

A Wireless Sensor Network can be defined as a network of devices that can communicate the information gathered from a monitored field through wireless links. A WSN can generally be described as a network of nodes that cooperatively sense and control the environment, enabling interaction between persons or computers and the surrounding environment. WSNs nowadays usually include sensor nodes, actuator nodes, gateways and clients. A large number of sensor nodes deployed randomly inside of or near the monitoring area (sensor field), form networks through wireless transmission. Sensor nodes monitor the collected data to transmit the data to the web server. During the process of transmission, monitored data may be handled by multiple nodes and after multi hop routing the data is transmitted into gateway node after, and finally reach the base station through the internet or satellite. It is the user who configures and manages the WSN with base station node, and collection of the monitored data. As related technologies mature, the cost of WSN equipment has dropped dramatically, and their applications are gradually expanding from the military areas to industrial and commercial fields. Meanwhile, standards for WSN technology have been well developed, such as Zigbee.

The main objective of this project is to monitor the pollution in the industrial area by using low cost and effective AQM system using arduino. The Air Quality Monitoring (AQM) is used to assess the extent of pollution for air quality to be maintained at good level. The goal of this pollution monitoring system is to alert the humans and protect the environment from harmful air pollution and also provides industrial authority to access air quality monitoring in real time.

In this project, we propose a pollution monitoring system and it measures the level of carbon monoxide gas and also measures the amount of dust particles present in the industrial area. In this system, the Ph sensor is used to detect the quality of water in the industrial area to improve soil quality and to avoid water pollution. The air quality of the industrial area is monitored by using the MQ 135 gas sensor and also measures the level of carbon dioxide present in the industrial area. The arduino process the data and the processed data measured by the sensors is transmitted wirelessly by using ESP 8266 wifi module to the web server.

The data collected from air quality monitoring helps us assess impacts caused by poor air quality on public health. Air quality data helps us determine if an area is meeting the air quality standards devised by CPCB, WHO or OSHA. The data collected from air quality monitoring would primarily help us identify polluted areas, the level of pollution and air quality level. Air Quality Monitoring system is carried out to assess the extent of pollution, ensure compliance with national legislation, evaluate control options and provide data for air quality monitoring.

Air pollution has caused many serious problems including climate change, loss of biodiversity, changes in hydrological systems, acid rain and stress on the system of food production. It is also known that some of the chemical pollutants in the air can increase the occurrence of diseases such as lung cancer and pneumonia. Air pollutants from the copper manufacturing industries result in the damage of ground level water and causes a major impact in respiratory

problems. Industrial polluted gases is one of the main sources for generating carbon monoxide that contributes 72% of total pollution in the metropolitan cities like Calcutta, Mumbai and Delhi.

II. EXISTING METHODOLOGY

In the existing methodology, air and sound pollution is monitored by using air quality gas sensor MQ135 sensor and sound sensor module is used. Basically the driver circuit is used to boost the power supply to small circuit components such liquid crystal display. In this system only air quality and sound pollution is detected by using suitable sensors. But as we know Carbon monoxide gas is highly poisonous to human beings, the existing methodology contains no CO sensor.

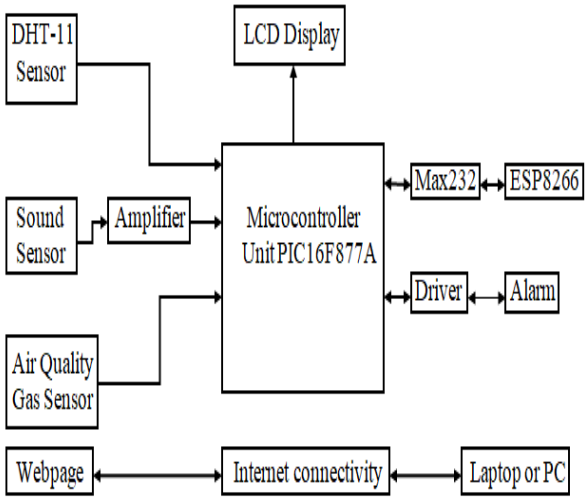

Fig.1 Block Diagram of Existing Methodology

DRAWBACKS OF EXISTING METHODOLODY

In the above Fig.1 the block diagram of Existing system only monitors Air and sound pollution and it does not have CO sensor to monitor the Carbon monoxide gas which is poisonous to human beings. Also, there is no pH sensor in the existing system which fails to monitor the quality of water content around the industrial area. In the existing system, DHT-11 Temperature and humidity sensor senses temperature only from the range of 0-50 degree Celsius and it cannot sense beyond the limit on manufacturing industries such as copper manufacturing sectors.

As there is no dust sensor used in the existing system, it could not monitor and predict the accurate level of dust particles present in the unit of micron levels. Also DHT-11 sensor senses only humidity of range from 20 to 80% which will not be effective in highly manufacturing industrial areas.

III. MATERIALS ANDMETHODS

A. Hardware Materials

Arduino Board: Arduino is a prototype platform (open-source) based on an easy-to-use hardware and software. It consists of a circuit board, which can beprogrammed (referred to as a microcontroller) and a ready-made software called Arduino IDE (Integrated Development Environment), which is used to write and upload the computer code to the physical board.

1. Arduino UNO R3:

The Arduino UNO R3 is a microcontroller board based on a removable, dual-inline-package(DIP)ATmega328P AVR microcontroller. It has 20 digital input/output pins in which six pins can be used as PWM outputs and six can be used as analog inputs. Programs can be loaded on to it and the user can execute based on specific application.

The operating voltage of Arduino UNO R3 is 5V and the clock speed is 16Mhz in which the programming interface can be done by USB via ATmega16U2.

Fig.2 Arduino UNO R3

2. ESP 8266 Wi-Fi Module:

The ESP8266 Wi-Fi Module is a self contained SOC with integrated TCP/IP protocol stack that can give any microcontroller access to your Wi-Fi network. The ESP8266 is capable of either hosting an application or offloading all Wi-Fi networking functions from another application processor. Each ESP8266 module comes pre-programmed with an AT command set firmware, meaning, you can simply hook this up to your Arduino device and get about as much Wi-Fi-ability as a Wi-Fi Shield offers. The ESP8266 module is an extremely cost effective board with a huge, and ever growing, community. This module has a powerful enough on-

board processing and storage capability that allows it to be integrated with the sensors.

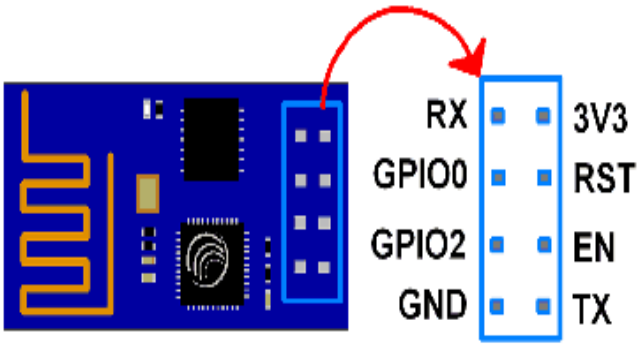

Fig. 3 ESP 8266 Wi-Fi Module

A. Sensor

The Air Quality and other parameters such as pH level of water content, dust sensity around the Industrial area is monitored by using suitable sensors such as DHT-22 Sensor, MQ-135 Air Quality Gas Sensor, MQ-7 Carbon Monoxide Sensor, GP2Y1010AU0F Optical Dust Sensor and pH sensor. The different parameters are sensed with equivalent sensors and the details of the sensors shown below.

i. Temperature and Humidity Sensor:

The **DHT22** is a commonly used Temperature and humidity sensor. The sensor comes with a dedicated NTC to measure temperature and an 8-bit microcontroller to output the values of temperature and humidity as serial data. The sensor is also factory calibrated and hence easy to interface with other microcontrollers.

The Operating Voltage of DHT-22 Sensor is 3.5V to 5.5V and the Operating current is of 0.3mA (measuring) 60uA (standby). The Output is of Serial data and the temperature Range is from -40°C to 80°C in which Humidity Range is 0% to 100%.The Resolution for Temperature, Humidity both are 16-bit and Accuracy is of ±0.5°C and ±1.

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DHT22 pins	
1	VCC
2	DATA
3	NC
4	GND

Fig. 4 DHT-22 Temperature and Humidity Sensor

ii.Air Quality Gas Sensor:

The air quality sensor is also a MQ-135 sensor for detecting venomous gases that are present in the air in homes and offices. The gas sensor layer of the sensor unit is made up of tin dioxide (SnO2); it has lower conductivity compare to clean hair and due to air pollution the conductivity is increases. The air quality sensor detects ammonia, nitrogen oxide, smoke, CO2 and other harmful gases. The air quality sensor has a small potentiometer that permits the adjustment of the load resistance of the sensor circuit. The 5V power supply is used for air quality sensor.

Fig. 5 MQ-135 Air Quality Gas Sensor

iii.Optical Dust Sensor:

GP2Y1010AU0F is an optical dust sensor by optical sensing system. An infrared emitting diode (IRED) and an phototransistor are diagonally arranged into this device.It detects the reflected light of dust in air. Especially, it is effective to detect very fine particle like the cigarette smoke. In addition it can distinguish smoke from house dust by pulse pattern of output voltage. It is a Compact, thin package (46.0 × 30.0 × 17.6 mm) Sensor. It provides low consumption current (Icc: MAX. 20 mA).The presence of dust can be detected by the photometry of only one pulse. It can sense and distinguish smoke from house dust.

Fig. 6 Optical Dust Sensor

iv.MQ-7 Carbon Monoxide Sensor:

They are used in gas detecting equipment for carbon monoxide (CO) in industry or car. The sensor is composed by micro AL2O3 ceramic tube, Tin Dioxide (SnO2) sensitive layer, measuring electrode and heater are fixed into a crust made by plastic and stainless steel net. The heater provides necessary work conditions for work of sensitive components. The enveloped MQ-7 have six pin, four of them are used to fetch signals, and other two are used for providing heating current. Resistance value of MQ-7 is difference to various kinds and various concentration gases. So, When using this components, sensitivity adjustment is very necessary. So the sensor is calibrated for detection of 200ppm CO.

Fig.7 MQ-7 Carbon Monoxide Sensor

v. pH Sensor:

pH levels are important in soils, irrigation water and spray tank solutions. Soil and water pH is the single most important aspect in determining nutrient availability to crops. pH levels in spray tanks determine the effectiveness of pesticides. It tests for soil alkalinity / acidity, soil moisture and sunlight. IN 1 moisture light & PH meter Soil analyzer meter is used. There is no battery required as it is simple and convenient to use. Simply by inserting the probe of the meter into the soil or water and by switching the setting the pH level of water can be measured and read the scale.

Fig.8 pH Sensor

IV. BLOCK DIAGRAM AND EXPLANATION

In this proposed system, Arduino UNO R3 is used which is a ATMEGA328 based microcontroller which operates at 16MHz clock speed. The amount of dust particles present in the industrial area is also monitored by using the optical dust sensor in terms of microns. The DHT-22 temperature and humidity sensor , MQ-7 Carbon monoxide sensor, MQ-135 Air Quality Gas Sensor, GP2Y1010AU0F Optical Dust Sensor, pH Sensor is interfaced with Arduino board. Once the Arduino is given power supply via a 12V adapter, the input sensors senses the different parameters such as the level of Carbon dioxide, Carbon monoxide and other harmful gases in terms of PPM (Parts Per Million) by using MQ-135 and MQ-7 gas sensors. The quality of water in the industrial area is also monitored by using the pH Sensor which measures the hydrogen ion concentration of water in the range of pH value from 0 to 14. If the pH of the water is less than 7, then the water is said to be in acidic nature and if the pH of the water is greater than 7 then the water is said to be in basic nature. The pH value of 7 is said to be in neutral state and can be recognized as good quality of water for human purpose. But practically, the pH value of water varies between 6 and 8. Also in this proposed system the switching technique is used in order to sense and monitor different area as unit-1 and unit-2 respectively.

The software part of the system is coded using HTML in the front end webpage and also PHP at the backend server. It is a scripting language designed to fill the gap between SSI(Server Side Includes) and Perl intended for the environment. The parameters sensed by the sensors can be monitored by using the MySQL database management system. The sensed data can be monitored in the form of database representation and also in the form of Graphical representation.

In the below Fig. 9 the block diagram of proposed system is identified andthe arduino analog input pin A0 is connected to the output pin of the MQ-135 Air Quality Monitoring. Sensor and the input pin A1 is connected to the output pin of the GP2Y1010AU0F Optical Dust Sensor. The pH sensor consists of two probes such as cathode and anode in which the 11th digital pin of the arduino is connected to the Tx port to sense the amount of hydrogen ions present in water.

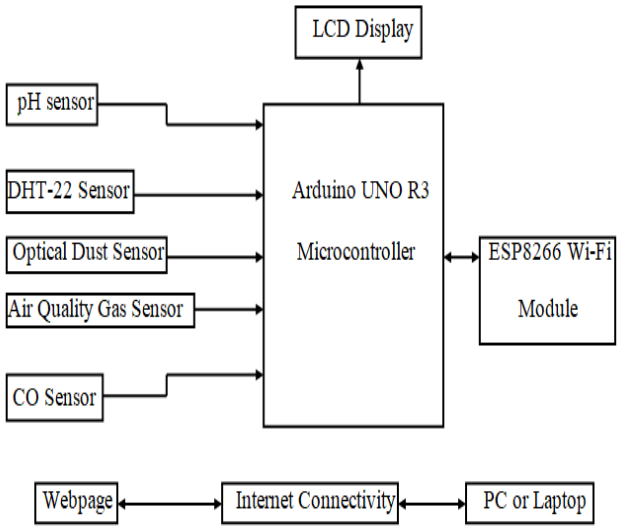

Fig.9 Block Diagram of Proposed System

The relay circuit is mainly used to withstand the high current cutoff to the temperature and humidity sensor and avoids the short circuit to the arduino because of the excess of current consumed by the sensor is dissipated as heat. The power supply required by the sensors is 5V with optical dust sensor being exemption as it requires 9V of power supply due to the excess of dust particles being sensed by the sensor with higher amount of heat.

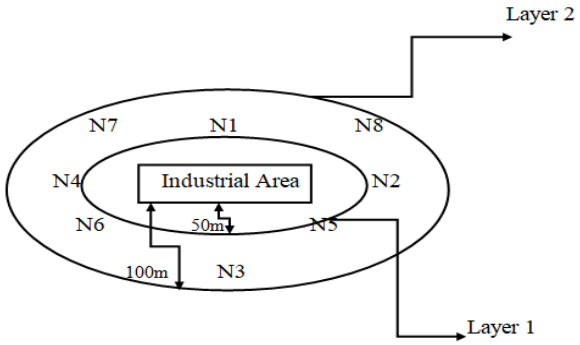

Fig.10 Structure of nodes to be placed around the Industry

In the above Fig. 10 N1, N2, N3, N4 is considered as nodes in Layer 1 and N5,N6,N7,N8 is considered as Nodes in Layer 2.The air quality will be monitored by using the number of nodes (i.e. Pollution monitoring system) placed around the layer of the industrial area at a distance of 50 to 100 meter

V. RESULTS ANDDISCUSSION

The ESP8266 Wi-Fi module consists of 4 pins such as TxD, RxD, RTS and CTS in which the 0th digital pin of the arduino is connected to the TxD port of the Wi-Fi module and the 1st digital pin of the arduino is connected to the RxD port of the ESP8266 module.

The LCD consists of 16x2 digital pins in which 2nd pin of the arduino is connected to the RS port of the LCD Display and it consists of the pins from D0 to D7. The 9th pin of the arduino is connected to the SPST switch in which it consists of one input terminal and one output terminal and also serves as on-off switches (i.e. When the switch is closed, the circuit is on and vice versa).

The Arduino analog input pin A0 is connected to the output pin of the MQ-135 Air Quality Monitoring Sensor and the input pin A1 is connected to the outputpin of the GP2Y1010AU0F Optical Dust Sensor. The pH Sensor consists of two probes such as anode and cathodein which 11th digital pin of arduino is connected to the Tx port to sense the amount of hydrogen ions present in water. The analog pin A2 of the arduino UNO is connected to the output pin of the MQ7 Carbon monoxide sensor and the 8th digital pin of the arduino is connected to the 2nd data pin of the DHT-22 temperature and humidity sensor.

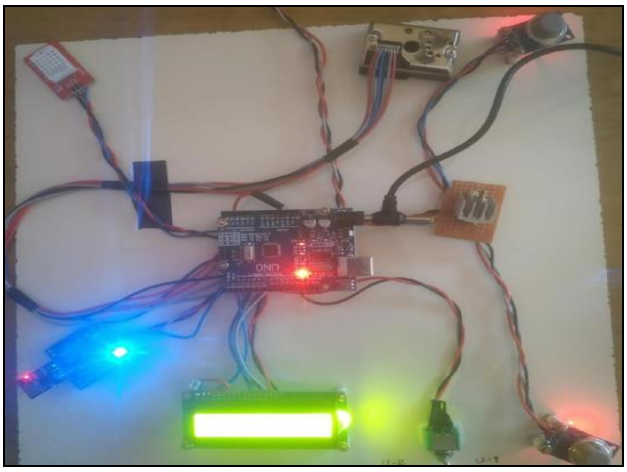

Fig.11 Industrial Pollution Monitoring System

In the above Fig. 11, it shows the complete setup of the Industrial pollution monitoring system based on WSN using Arduino UNO R3. A 12V adaptor is used to give power supply to the arduino UNO R3 microcontroller and the processed data are transmitted wirelessly to the web server by using the ESP8266Wi-Fi Module by accessing the internet connectivity via Wi-Fi through the hotspot of the mobile or PC. The SSID of the mobile network must be known to the user before connecting the PC to the Wi-Fi. Then after connecting to the specific SSID,the parameters can be monitored by using the web page and the data can be viewed in the form of graphical representation in separate graph for each parameter.

In the below Fig. 12, LOGIN PAGE of the webpage is programmed using HTML and PHP codes. By entering USER ID and PASSWORD, the next webpage of the website displays.

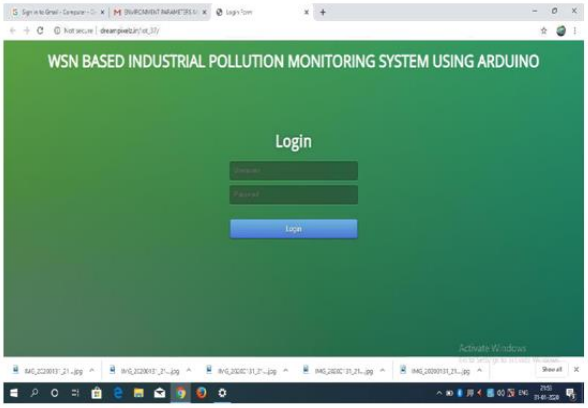

Fig.12 LOGIN PAGE.

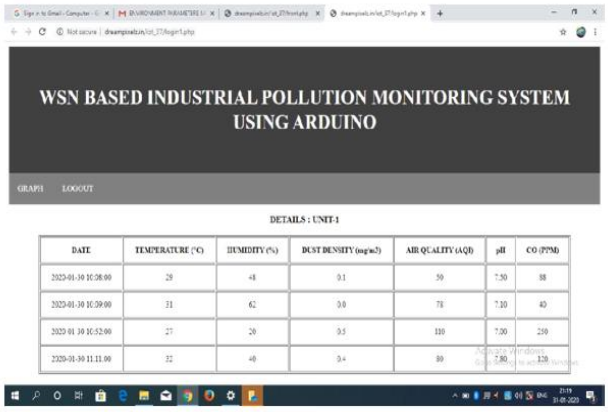

Fig. 13 Unit-1 Data Measurement

From the Fig. 13, it shows the data measured in Unit-1 can be monitored and different parameters such as temperature, humidity, dust density, Air Quality Index(AQI), pH level, CO content in terms of PPM can be measured in one area.

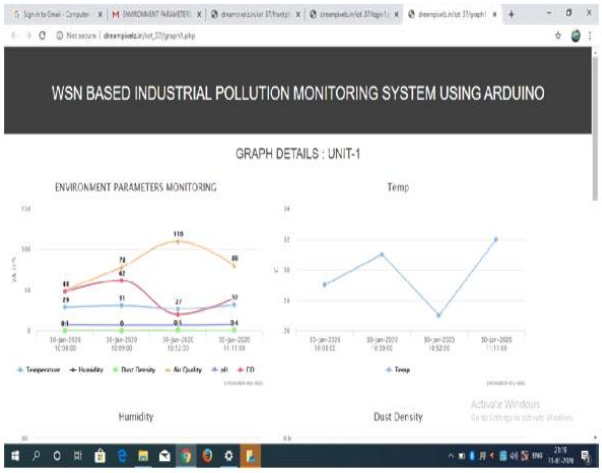

Fig.14 Unit-1 Graphical Representation

From the above Fig. 14, it is identified that the parameters measured from the system can be monitored in unit 1 and the data can be monitored in the form of graphical representation and each parameter is also separately monitored in the form of graphical representation.

VI. CONCLUSION AND FUTURE ENHANCEMENT

This Project provides an innovative solution to monitor the air pollution and also monitoring the level of harmful gases which will help industries to control the Pollution. It also allows the people to know about the level of Air quality in the atmosphere by login the website.

The project concludes about the measurement of various parameters such as temperature, Humidity, Air Quality Index, Dust particles, pH content of water, Carbon monoxide gas. These are monitored by using Arduino UNO R3 which is a ATMEGA 328P microcontroller in which the coding can be reprogrammed according to the user application. By accessing the webpage, the level of gases and air quality can be monitored in different area such as unit-1 and unit-2.

This project can be enhanced by using GSM and GPS technology where the location of the polluted industrial area can be monitored and intimated through text message to the industrial unit officials. Also, the software programming can be enhanced by allocating specific threshold values for the sensors to alert the industrial area and thepeople around it.

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