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An Integrated Model of IoT and Cloud for Detecting Green House Gas Emissions

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Abstract*: Chennai is one of the oldest metropolitan city in India which consists of 15 zones and more than 200 wards. Chennai has the population of more than 8 million people and more than 20 tons of garbage collected and dumped into the two of the dumpyards Kodunkaiyur and Perungudy. These two dumpyards are catering the needs of the garbage and landfills collected from these zones, in which they are used to burn and disposed. The burning of waste is resulted into emission of higher amount of CO2. The decayed waste is one of the source for generating Methane and other greenhouse gases. This is dangerous for human lives and affects the environment. There is no such system has available to detect the CO2 and CH4 level automatically at these dumpyards. If a system automatically detects the level of CO2 and CH4 and make it available in a public domain, it will be helpful to the city administration to take the precautionary steps. Therefore, the need of the hour is to design a cloud enabled IoT based system to monitor the level of CO2 and CH4 and upload these data in the cloud for further processing. The sensor is installed in 20 of different places of these two dumpyard for monitoring the level of CO2 and CH4. The data is collected and uploaded in the cloud. The open source cloud platform Openstack is used to store all the recorded data into the cloud. The webpage www.chennaighgemissions.in is designed and the sensed data is available for public use. The system is successfully implemented and tested, and the test result is promising.

***Keywords* : Green House Gas, IoT, Openstack Cloud.**

I. INTRODUCTION

Chennai is one of the oldest metropolitan city in India with the population of over 90 lakhs people living in the city. Over 3600 tons of garbage is collected every day from various places and transferred to dumpyards. There are two dumpyards Kodunkaiyur and Perungudy with the capacity of 269 acres and 200 acres respectively for catering the needs of disposing solid wastes and building debris. The report shows that the average garbage of 650 Gms is generated by an individual daily. The garbage are collected by various sources and segregated as solid waste, plastic and bio-degradable and non biodegradable waste etc. The bio-degradable organic waste is processed at the dumpyard station itself and solid waste are recycled. In essence, Ozone layers used to protect our earth from high temperature and other radiation from the solar system. The increasing quantum of carbon dioxide emitted from various sources like automobile, electricity production, transport and other industrial hazards polluted the environment more. The higher the carbon is dangerous to the human as irritation in eyes, skin deceases and it leads to cancer. Another important threat to human lives is methane (CH4). The higher the level of methane which impacts subsequently affects the human and environment. Both elements are dangerous and the higher the level which leads to the depletion of ozone layer. This leads to severe damage to environment and living natures. Furthermore, the cyclic nature of environment will be affected and these two elements are further influences the phenomena of climate change. Climate change affects the environment with key elements like rising temperature, loss of rainfall, risen of sea level, severe downpour, drought etc. Dumpyards are the one of the source for generating CO2 and CH4 vehemently. The survey shows that the burning of the wastes from these dumpyard posing severe threat to the nearby people and the remedy measures are recommended to corporation for reducing the impact. In this paper, the level of CO2 and CH4 is monitored with the help of Internet of Things (IoT) and the data is collected and stored into the cloud. Furthermore, the level of CO2 and CH4 is analyzed for taking precautionary measures. The total of 40 sensor node for CO2 and CH4 is installed in Kodunkaiyur and Perungudy dumpyards. These sensors output the levels CO2 and CH4 data continuously and send to the openstack cloud server and web server. From the server the data is processed and the range is analyzed. If the range is higher than the threshold value, the system sends an alert to the concerned officials. The monitored data is available in the public domain for future reference.

A. Related work

Numerous papers are presented for the effects of CO2 emissions and the consequences of higher the CH4. These works are concentrating the measurement of CO2 emissions manually and limited in automatic detection. The proposed work is focused on monitoring and measuring greenhouse gases at dumpyard automatically. In [1], CO2 enrichment technique is discussed. Quantifying city scale CO2 emission is discussed and presented a strategy to reduce the level of CO2 is discussed in [2]. In [3], restoration of marsh land is discussed. This marsh land is near to the Perungudy dumpyard. Researchers have used several models including first-order decay model in [4], IPCC Waste model, and LandGEM model [5] for estimating the CH4 generation rate. While the other models do not support the estimation of CO2 generation from the waste, LandGEM model can be used to estimate both CO2 and CH4.

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To foresee the quantum of emission to be possibly reduced by adapting to newer technologies to mitigate the waste generated, an attempt has been made to monitor greenhouse gas concentration within 5 km radius of both Kodunkaiyur and Perungudy dumpyards.

II. PROPOSED SYSTEM

A. Methodology

The architecture of the proposed system is shown in figure1. To measure the level of CO2, the MG-811 sensor is utilized. The range of this sensor is between 350 – 10,000 PPM (Part Per Million). The sensor incorporates with two electrodes namely metal oxide material and heater. The Electromotive Force (EMF) is generated when a CO2 is detected. The concentration of gas CO2 is logarithmically related to EMF. Due to the fact that the sensed data of EMF is very low, the booster is required to amplify the signal.

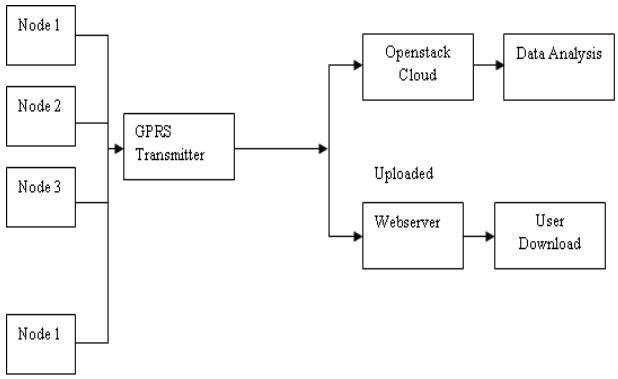

Figure 1. Overall architecture of the proposed system

Using regression on graph we can define the straight line as

Y=-16.439x+43.84 (1)

With R2=0.9974

To find concentration C, We can simplify the equation from (1) to derive

C=10(-16.439*log10(V)+43.84) (2)

B. CH4 sensing device

The methane (CH4) gas is sensed by TGS2600 sensor. The sensor is equipped with metal oxide sensing material and heater is inbuilt between two electrodes. The sensor can detect the CH4 in the range between 3-100 PPM. This sensor is also works the same as MG-811. The resistance between electrodes has been changed when the methane gas is exposed. The resistance of clean air is denoted by R0 and its value is 20000 Ω. In the case of test air, the resistance is denoted Rs. The log10 is related with the concentration of methane and it is defined in the following linear equation:

$$Y = -10.012 \times \log_{10}(R_s/R_0) + 0.5391 \quad (3)$$

With R2 = 0.994

The concentration C of methane for the test air can be derive from the above equation as

$$C = 10^{(-10.012 \times \log_{10}(R_s/R_0)+0.5391)} \quad (4)$$

DH-11 sensor is used to measure the temperature and humidity. The humidity is sensed in the range of 20-90 RH and with the error range of ±4% RH. The temperature is sensed in the range of 0-50^o C with the error range of ±2o C. these four sensors are connected with Arduino processor and these sensors are connected with serial interface. When a query made these sensors are responded with response time of one second with a 40 bit binary string data.

The GSM/GPRS of Arduino is connected through the shield with port. This shield equip with a SIM900A chip, a dual band antenna and a SIM card. The communication of GSM/GPRS is through modem and AT commands. The USART (Universal Synchronous Asynchronous Receiver Transmitter) serial communication is used to understand, send and receive AT commands. The chip is designed such a way that it can able to send and receive TCP/IP based HTTP protocol.

The figure 2 shows the overall connection of Arduino central processing unit with MG-811 and TGS-2600 sensors.

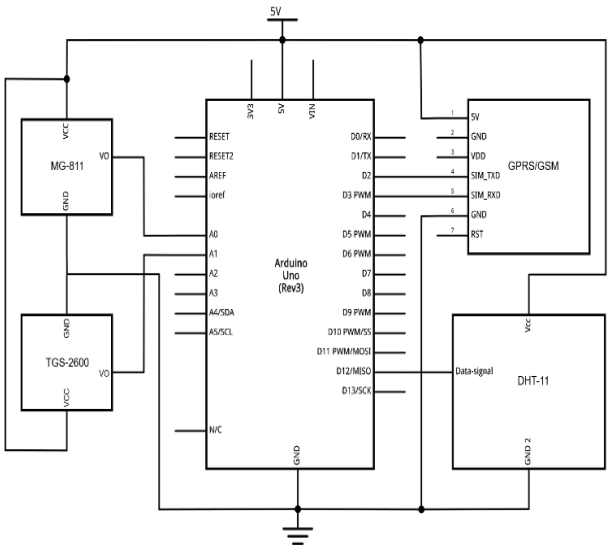

Figure 2. The overall connection of Arduino with

The Arduino consist of six analog input pins and fourteen digital output pins. It also has a 32 KB flash memory. The board is in operation mode by using 5V through USB or 7-12 V from direct current. The board is burnt such a way that it can load user programs and provide the result without any external interference. All four sensors are connected serially and the sensed data is generated as an output.

III. EXPERIMENTAL RESULTS

The system is implemented with the Arduino board equipped with MG-811, TGS-2600 and DHT-11 sensor for sensing Carbon di-oxide, Methane, Temperature and Humidity respectively. Total of 40 Arduino nodes are installed in Kodungaiyur and Perungudi dumpyard with 20 nodes for each area. These nodes are configured with five nodes in a radius of one cycle. Four cycles are formed in each area for detecting the emission of Green house gases such as CO2 and CH4. All five nodes are installed in a circle of radius with equal distances. The nodes are successfully installed and the sensors captured the data and with the help of GPRS module, the data is transferred to Openstack cloud and Web server.

The concentration of CO2 is sensed by MG-811 sensor and the collected data is transformed into the understandable format using the equation (1) and equation (2). Similarly, the concentration of CH4 is sensed by TGS-2600 and the sensed data is translated by the normalized form using the equation (3) and (4). Furthermore, the temperature and humidity is captured by DHT-11 sensor. The output of the sensed data is stored into the Openstack cloud. An instance created from the openstack and the date is collected and stored. The data is collected with regular interval and stored. Furthermore, the stored data in the cloud is analyzed with the help of machine learning algorithms. The future trend of CO2 and CH4 is analyzed using the past history of the data. The SVM and Random forest algorithms are applied with the data and the accuracy of prediction is analyzed. For publishing the data in a public domain, a web page is designed to keep all the data in the archives. It is openly available for public use. The sample data is shown in table 1.

Table 1: Recorded data by the sensors of a node

TEMP (°C)	HUMIDITY (%RH)	CO2 (ppm)	CH4 (ppm)	TIME
36	57	498.54	4.67	14:35:23
41	52	438.73	4.93	14:38:45
38	50	438.73	5.15	14:43:31
38	51	369.73	5.53	14:48:35
37	54	465.76	3.67	14:58:48
36	57	563.28	5.94	15:03:03
36	55	369.73	4.53	15:18:29
36	58	446.64	5.2	13:46:06
34	61	580.89	6.2	12:12:07
36	32	420.48	5.1	10:56:05
35	30	490.63	1.42	11:59:20
30	29	544.97	1.3	12:08:53
32	30	359.43	1.88	12:16:18
36	29	359.43	1.88	12:26:37
37	28	398.45	1.71	12:44:04
37	26	359.43	1.88	12:55:44

The data represented in table 1 is shown in figure 3.

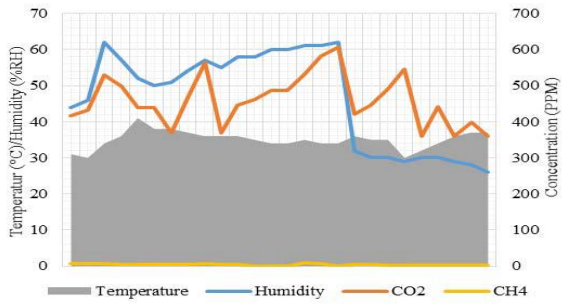

Figure 3. Graph shows the concentration of CO2 and CH4

The graph shown in figure 3 depicts the concentration level of CO2, CH4, Temperature and Humidity. The recorded data of CO2 and CH4 is measured by the unit in PPM. The web page http://www.chennaighgemmission.org is designed to publish the CO2 and CH4 data into the web page.

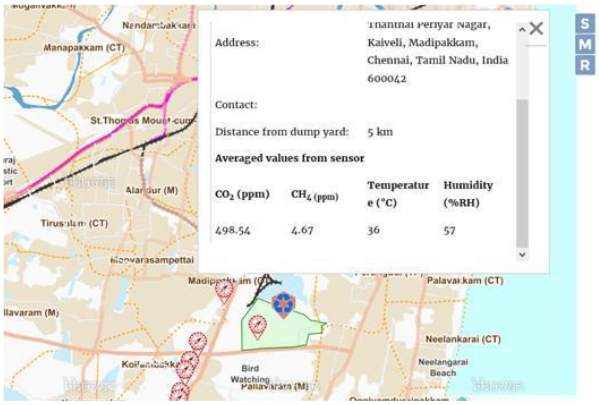

Figure 4. Data retrieved from www.chennaighgemission.in

Anyone can download and view the level of CO2 and CH4 for a day from our website. The future trends of the CO2 and CH4 is predicted using random forest and SVM approach for a particular day. The past history of data is considered as input and predicted. Table 2 shows the accuracy of the prediction.

Table 2: Comparison Of Prediction Accuracy

ALGORITHM	PRECISION	RECALL
SVM	89.56	85.22
Random Forest	92.45	89.44

The performance of the prediction of the two algorithms is compared and the accuracy is shown in Table2. The Random Forest algorithm shows good performance comparing with the SVM algorithm.

IV. CONCLUSION

Cloud based Greenhouse gas emission is successfully detected with the help of IoT and opentack cloud techniques. The system is successfully implemented and the CO2 and CH4 data is recorded using the designed sensors and system. The system successfully uploaded the data into the cloud using GPRS module. Furthermore, the recorded data is successfully processed and uploaded into web server for public use so that any one downloaded from the website. The system limited in working with varied weather conditions like rain and other climatic changes. Furthermore, some manual intervention is required for processing the data currently. In future, fully automated system can be designed to fill the gaps. The research for encrypting and decrypting data using suitable encryption/decryption algorithms is under progress. These techniques enhance the data security.

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