# Vehicular Emission Monitoring using an Internet-of-Things System

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**Abstract**

A major source of air pollution in a bustling metropolis is vehicular emission. To address this problem of increasing air pollution due to vehicular emission, cities have applied several parameters like the Odd-Even" rule for driving vehicles.

In this work, we develop AirCheQ, an Internet of Things (IOT) system that measures several gases that originate from vehicular emission. The setup is built using the Raspberry Pi platform and connecting several gas sensors and other environmental monitoring devices that senses gases and other environmental conditions, and wirelessly sends it to a server for visualization and analysis. The system is location aware, and shows real time vehicular emission information on a Google Map Interface.

## Introduction

- Air pollution in metropolitan cities is rising at an alarming rate. To tackle this issue, first step is to make people aware of the problem.
- Using the Internet-of-Things system with participatory sensing, the project collects several environmental data from a large subset of the pollutants in vehicular emission
- AirCheQ aggregates the crowd sourced data and exhibits it in a visually appealing and meaningful manner.

| Software Requirements | Hardware Requirements |
|---|---|
| Java SE (Oracle JDK 8) | Core Setup Requirements – Raspberry Pi 2 Mod B |
| Java EE (Oracle JDK 8) | Sensing Requirements (Sensors) |
| Python (v2.7) | Belkin USB Bluetooth Adapter |
| Meteor (Full Stack of Blaze and MongoDB) | Nolan GPS Receiver |
| Android Studio (v1.5.1) | Tenda USB WiFi Module |
| Raspbian OS (v Jessie) | Server Machine / Cloud |
| | Power Bank, ADC, Android Smartphone |

**Figure 1:** Table depicting the Software and Hardware requirements of the project

| Environmental Parameter Sensed | Sensor(s) used to detect |
|---|---|
| Carbon Dioxide | MQ135 |
| Smoke | MQ2 |
| Methane | MQ4 |
| LPG | MQ6 |
| Carbon Monoxide | MQ7, MQ9 |
| Humidity | DHT22 |
| Temperature | DHT22 |

**Figure 2:** Table depicting the sensor used for each of the environmental parameters

## Problem Description

- This project is designed to serve as a prototype for a crowd sourced external environment monitoring system
- The project involves using a Raspberry Pi 2 Mod B equipped with multiple MQ-X sensors coupled with DHT22 sensor which work as the input source to sense various gases, temperature and humidity levels.
- A Bluetooth enabled GPS receiver connected to the Raspberry Pi acts as a neighbourhood sensor and serves as a reliable source of geolocation for the setup.

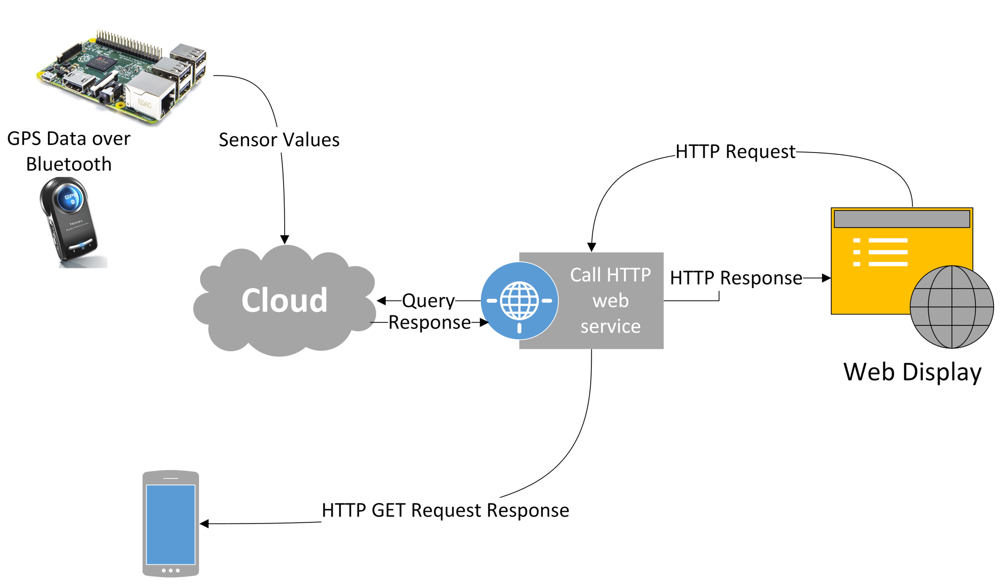


**Figure 3:** A high-level diagram explaining the entire IoT setup for AirCheQ

## Project System Setup

The AirCheQ Project is majorly made up of two components: The Hardware System Setup and Software System Setup. Although the Software System consists of a Web System Setup and an Android Application.

## Hardware System Setup

- A fully function Raspberry Pi 2 Mod B installed with Raspbian Jessie OS.
- While the digital DHT22 sensor can be directly read, analog gas sensors need to be interfaced to an ADC MCP3008 and calibrated in order to sense the desired gases.

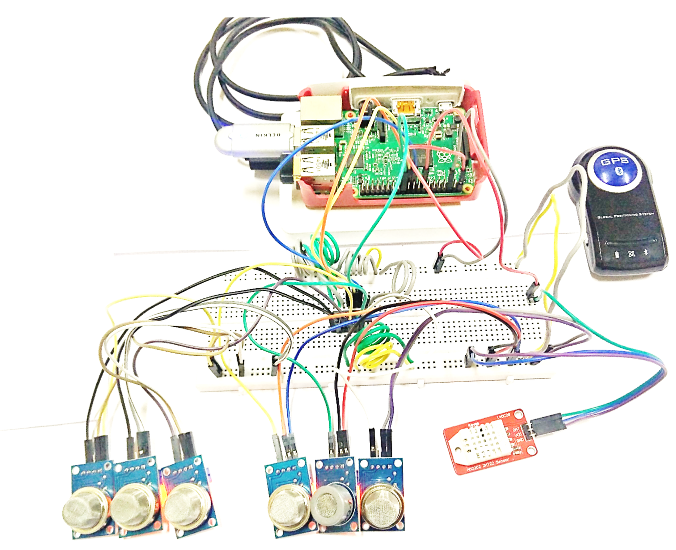

**Figure 4:** The prototype hardware setup with 6 MQ-x sensors and DHT22 sensor interfaced to the Raspberry Pi 2 Mod B along with the Bluetooth GPS receiver and Belkin USB BT adapter

- The Bluetooth GPS receiver requires a Bluetooth USB adapter to connect to the Raspberry Pi. The NMEA sentences sent by the GPS receiver are used to deduce the latitude and longitude.

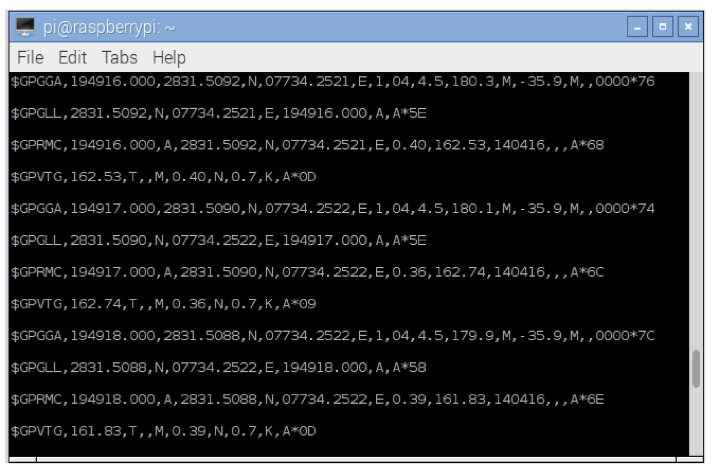

**Figure 5:** COM port showing the NMEA sentences when the GPS is on at SNU, Hostel 3A

## Software System Setup

- The software system setup of AirCheQ has 3 major components: Meteor Server, Java web service and the Android Application.

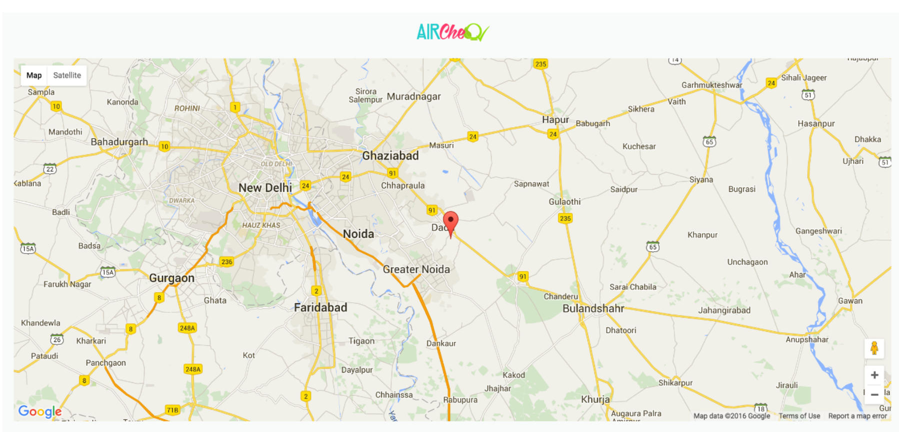

**Figure 6:** The homepage of the website opens up with markers from where the data is collected

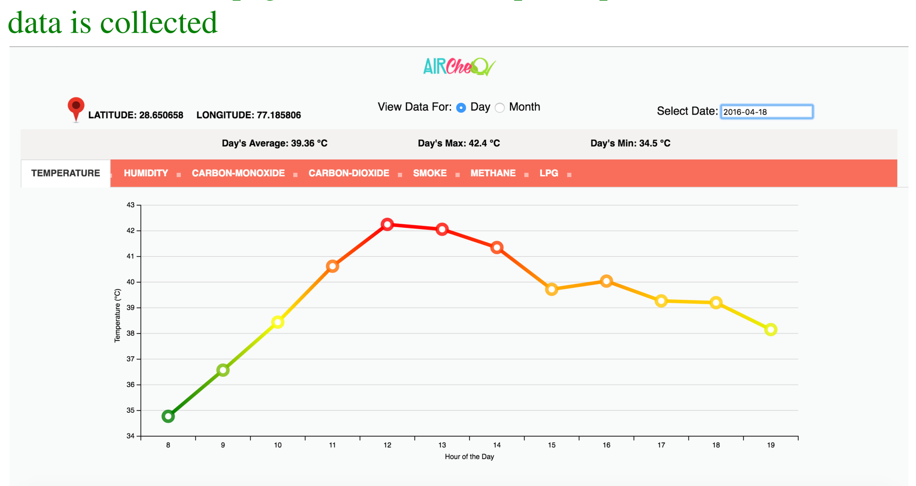

**Figure 7:** Temperature Data collected in Delhi on 18 April 2016

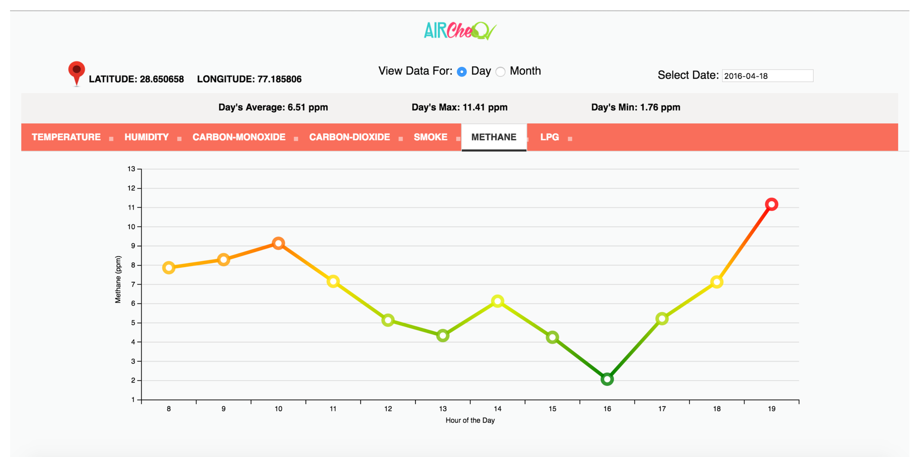

**Figure 8:** Methane Data collected in Delhi on 18 April 2016

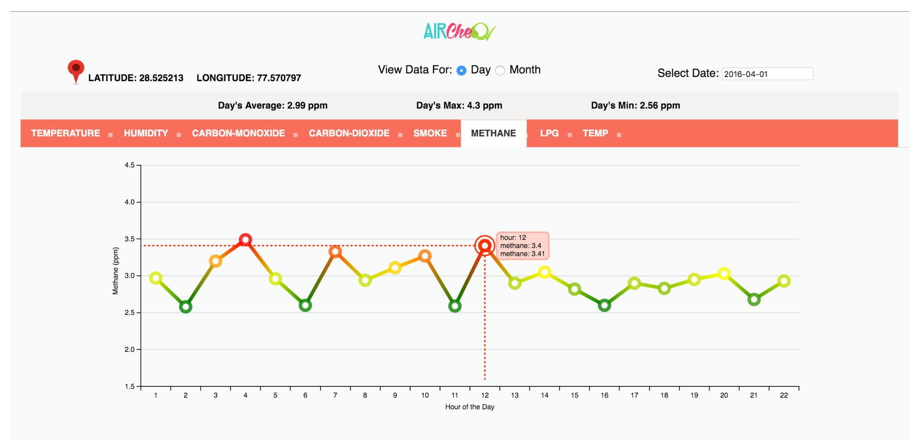

**Figure 9:** Hovering over a data point of Carbon Monoxide draws its x and y intercepts

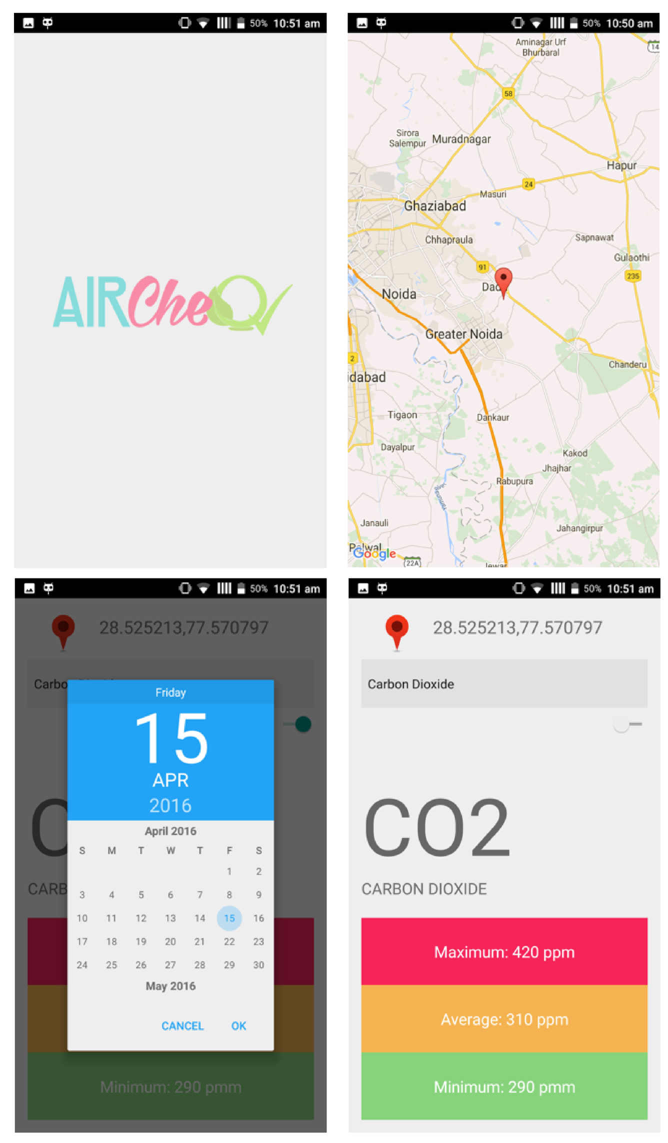

**Figure 10:** Screenshots of the AircheQ Mobile App

- The Web Service acts an interface between the UI and the Database. Both Web App and Android App load up with Google Maps populated with location markers. Clicking these markers redirects the users to Graph View in the Web App and a Quick PPM View in the Mobile App.
- The developed Web Application is reactive and shows real time data by syncing with the DB automatically.

## Conclusion

- A fully functional IoT participatory data collection system was developed. Successful sensing of various vehicular emission components like carbon dioxide, carbon monoxide, LPG, methane, smoke was achieved. Use of incentive schemes, be it monetary or non-monetary, could be a possible solution to increase the number of users.

## Acknowledgement

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