IoT enabled indoor air quality monitoring system for sustainable health management in an industry laboratory, a case study

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Abstract

The Internet of Things (IoT) provides a platform that allows devices to connect, discover and remotely control through the internet. This work aims to develop an Internet of Things-based system for an oil company's laboratory. It is intended to monitor its environmental conditions and parameters through air quality sensors, thus providing intelligent monitoring and greater certainty of working conditions. The system development utilizes ESP8266, Arduino UNO processor, solid-state relay, and sensors. The proposed work monitors the air quality, humidity, and temperature of the laboratory environment. It included an active air exhaust control system. A database has been created with the purpose of data analysis and access to status history. As a result of this system implementation, it is expected to improve laboratory management and occupational health and hygiene.

Keywords
COVID-19, Health, IoT, Ventilation, Air Quality

1. Introduction
In our country, many systems are disconnected and do not share data with each other or with the cloud. One of these technologies that facilitate interconnection is the Internet of Things. The Internet of Things is a communication paradigm, which refers to the idea of connecting everyday objects to the Internet (Chen Qiang et al., 2008). These objects are assembled with microcontrollers and transceivers to enable communication and are configured with protocols that will perform interactions between objects to achieve common goals without human intervention. This paradigm gains power by interacting with a variety of devices, such as: robots, drones, heating and air conditioning systems, security alarms, home appliances, power generation systems, office equipment, etc. These devices generate large amounts of data to provide people and new services provided by the public and private sectors. As the industry develops year after year, new management issues and management problems have emerged. This has become a real problem. The supervision and control of the workspace is also a major shortcoming. In addition, when the number of people using the space exceeds a manageable threshold, it can become tedious to coordinate the personnel involved in the daily activities of the laboratory. Another problem is energy management.

It is difficult to control all subsystems, such as lighting and exhaust systems. But if they are placed indiscriminately, energy will be wasted. You cannot easily check the status of the subsystem. To solve these problems, Internet of Things technology is a suitable method. IoT smart devices can replace some traditional devices, connect subsystem devices with each other, and better connect to the IoT network. When things are automated, manual work is reduced. The need for this work is to reduce manpower by automating laboratory resources, to realize the future laboratory model using Internet of Things and effective use of laboratory resources and energy management (Momoh, 2009).

1.1 Objectives
This study aims to help chemical testing laboratories find out the factors to be considered when implementing IoT-based technologies and design the correct IoT technology priority selection for chemical testing services.

2. Literature Review
The definition of the Internet of Things (IoT) is that it allows people and things to connect to anything, use the network in any way, and transmit information and data from any place, any time, and anyone. Because of the use of the Internet, everything in the world relates to others on a global scale. Thanks to smart things (objects), such as devices with sensors, mobile phones, smart gadgets, wearable devices, and laptops, environments around the world are becoming smart, such as smart cities, smart industries, smart homes, and smart health System, high mobile equipment, and high network flexibility (Hidayatullah et al., 2017).

The reason is that in the past 15 to 20 years, devices have become cheap, available, and small, and all aspects of life have been automated through Internet connections (Saari et al., 2016). Many researchers are working on the Internet of Things and point out that the network has undergone many evolutions to make it more reliable, more efficient, more flexible, and suitable for the next generation. They also highlighted a shocking stage, that is, the number of devices that people connect to the Internet is growing rapidly and may reach or exceed 50 billion by 2020. The number of devices will gradually increase over time. The advancement of the Internet of Things must consider issues such as how to integrate and interoperate a single network and many heterogeneous sensor devices.

In addition, in terms of different types and sizes of data or information, various transmission capacity requirements from many applications, and unfathomable time and error recovery capabilities, the communication requirements to support the Internet of Things are significantly different from current systems. Remote connection is making the world as smart as a smart city.

3. Indoor air pollution and air quality standards
Indoor air pollution is ubiquitous and, in many forms, from the smoke produced by the burning of solid, liquid and gaseous fuels in the home to the complex mixture of volatile and semi-volatile organic compounds, particulates and gases present in modern buildings. The design and construction of modern buildings aims to conserve energy by limiting the exchange of air between indoor and outdoor environments. In these buildings, many synthetic materials and chemical products have been used to achieve the desired goal of energy saving by maintaining a constant air temperature in the building.

In this way, the blend of low ventilation rate and the presence of various wellsprings of manufactured synthetics has brought about raised convergences of unpredictable natural accumulates in the advanced structures all through the world. The term 'wiped out building condition' has been begat by specialists to clarify the issue of tenants of such present-day structures griping about disease disorders.

Poor indoor air quality has been credited to the worsening of numerous illnesses including respiratory sicknesses, hypersensitivities, disease, asthma, and numerous other therapeutically unexplained indications. Local case studies on ventilation analysis were conducted using Computational Fluid Dynamics (CFD) tools to verify proper air flow in the COVID context (Kurita et al., 2020).

Associations have progressively been embracing ICT to work on the proficiency, usefulness, and productivity of their tasks.

The utilization of ICT alongside other office mechanization apparatuses has carried numerous electronic gadgets into the workplaces and tables of representatives. Out of these gadgets, PCs, printers, scanners, and copy assume the conspicuous position.

Generally, these gadgets are worked inside bound spaces, for example, exceptional desk areas designated for explicit tasks or inside the space involved by the actual representatives.

Anyway, these devices have chipped away at the business and the individual fulfillment of people, they have similarly found to cause a couple of prosperity related issues. During the justification their movement, these contraptions have been seen to deliver a couple of gases and particulate issue close by radiation of electromagnetic waves at various frequencies. The laser printers and scanners utilized in the workplaces utilize a substance called toner in their printing activities. The toner is a very fine powder that has been utilized to make the picture on paper. This toner might spill from the gadgets into the climate because of different reasons including spilling of the residue inside the gadget, harmed cartridges, or reckless giving of cartridges during reloading and so forth These fine particles of toner might cause respiratory issues in individuals including asthma, bronchitis, windedness, non-hypersensitive rhinitis, sore throat, hack, pseudo unfavorably susceptible aggravation of the respiratory lot, upper respiratory plot contaminations, skin, and eye disturbances.

Notwithstanding the spillage of toner, scanners have likewise been found to emanate gases like O3, NO2, CO, CO2 and unpredictable and semi-unstable natural mixtures. These gases and natural mixtures cause different medical conditions including eye, nose or throat disturbance, migraine and weakness, wheezing, hacking, bewilderment, sickness, skin aggravation, respiratory and cardiovascular issues. These gases or poisons are by and large isolated into two gatherings as essential contaminations and auxiliary toxins. Essential poisons are the ones that are transmitted straight by the hardware during the tasks. NO2, CO2, CO and SO2 are run of the mill instances of essential contaminations transmitted by scanners. Then again, optional contaminations are shaped by responses of the essential toxins with one another or normally happening compounds in the environment. The usually realized optional poisons incorporate O3 and other photochemical oxidants created during the daylight started responses of nitrogen oxides, unpredictable natural mixtures (VOCs), and carbon monoxide. Out of these optional contaminations, O3 is one compound that is both useful and unsafe to human wellbeing. O3 is a temperamental and henceforth a profoundly responsive type of oxygen. The O3 particle is comprised of three oxygen iotas bound together, while the oxygen (O2) that is fundamental for living contains just two oxygen molecules.

4. Proposed work

The square outline of the proposed gadget is displayed in the Figure 1 and Figure 2. The temperature and dampness sensors identify with a MQ-5 sensor to an ESP8266 miniature board that gathers the sensor information and sends it to the Internet through the Wi-Fi module. The lab professionals (Figure 3) can get to the individual data in the cloud (Thingspeak) whenever. Web of Things is acknowledged by utilizing Thingspeak, which is an open-source cloud administration. Continuous checking information is moved from the ESP8266 microcontroller to the Thingspeak cloud.

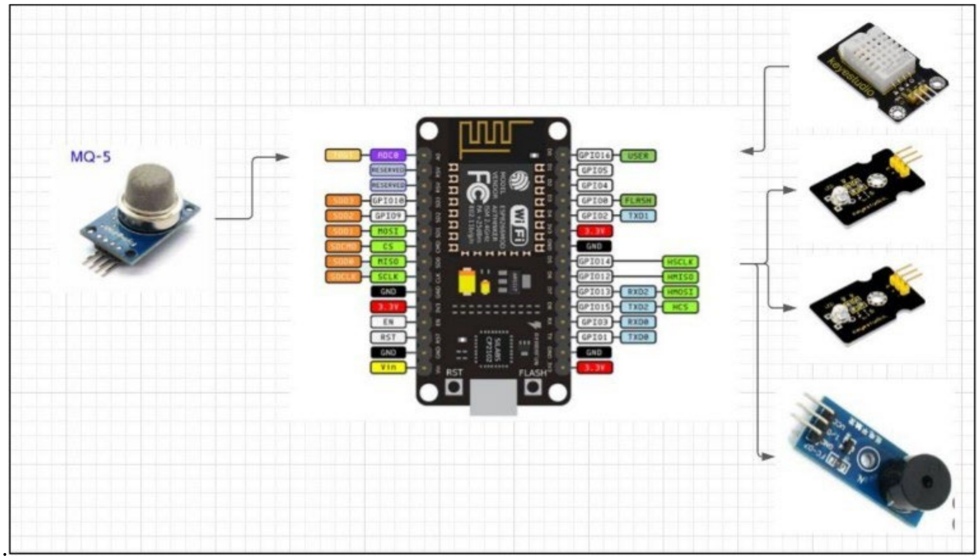

Figure 1. System Architecture for proposed gas monitoring device.

Figure 2. 3D printed Sensor box.

Figure 3. Chemical testing laboratory.

4.1. Equipment Operation

The equipment through the sensors obtains data to determine the state of the environment (temperature, humidity, particles per million of the gases present) and depending on the levels the equipment informs that the environment is not good for activities.
The data obtained is also sent to a web page that functions as a database and visual interface for users with meters and graphs that help the understanding of the data flow that is updated every 15 seconds.

4.2. Components

The following components were purchased from local electronics stores. They are all OTC.

- MQ-5 air quality sensor
- DTH 22 temperature and humidity sensor
- LED MODULE
- BUZZER MODULE

5. Results

The graphs clearly show (figure 4, 5, 6) the entry of personnel, the change in temperature and humidity as well as the constant increase of particles in the environment as personnel remains in the laboratory.

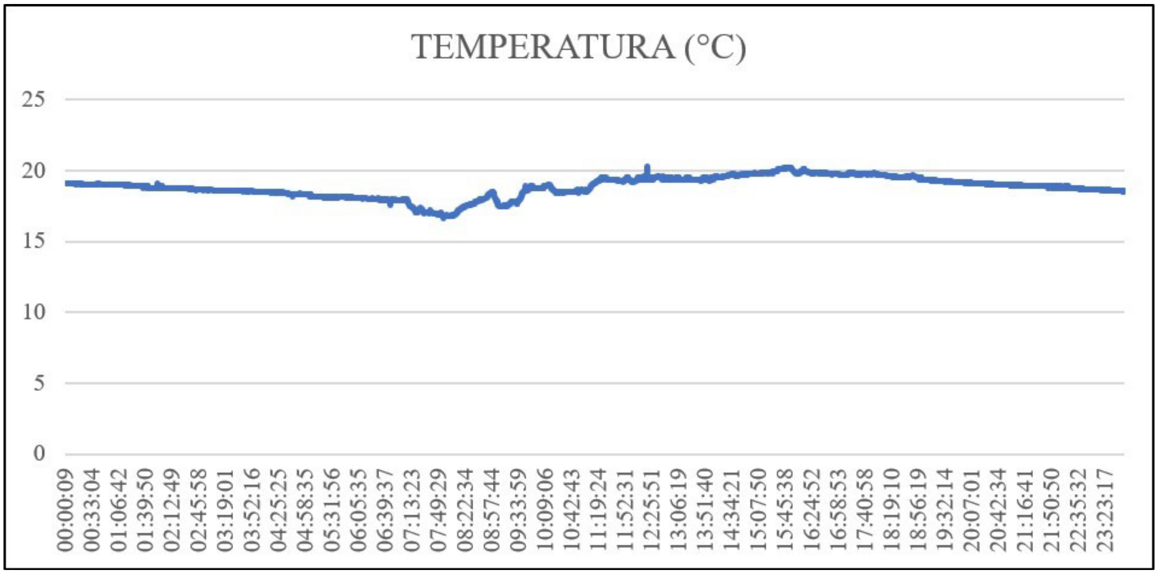

Figure 4. Temperature data sampled during a day.

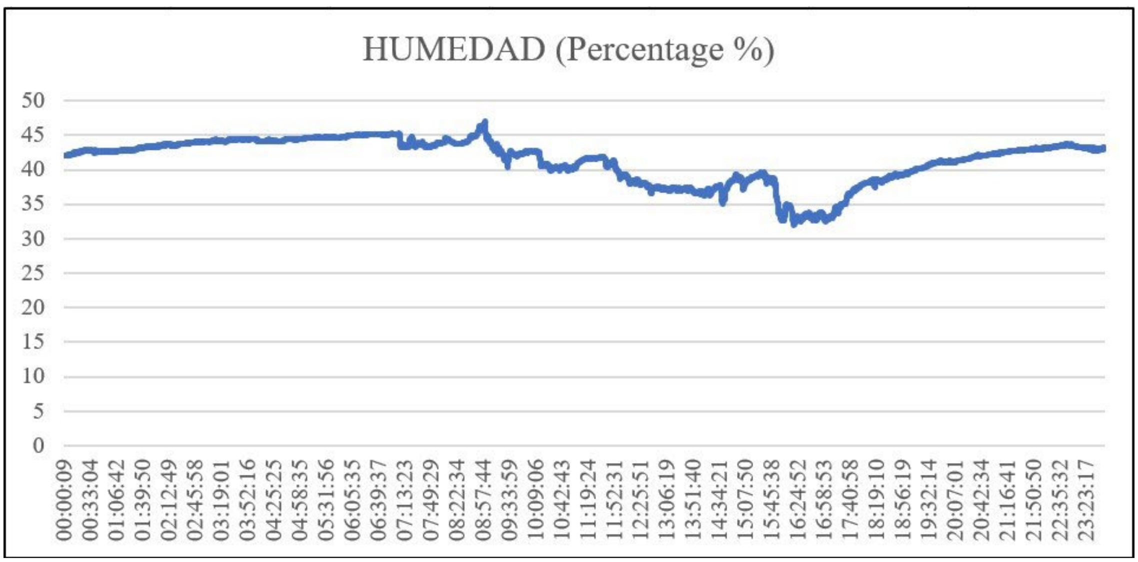

Figure 5. Humidity data sampled during a day.

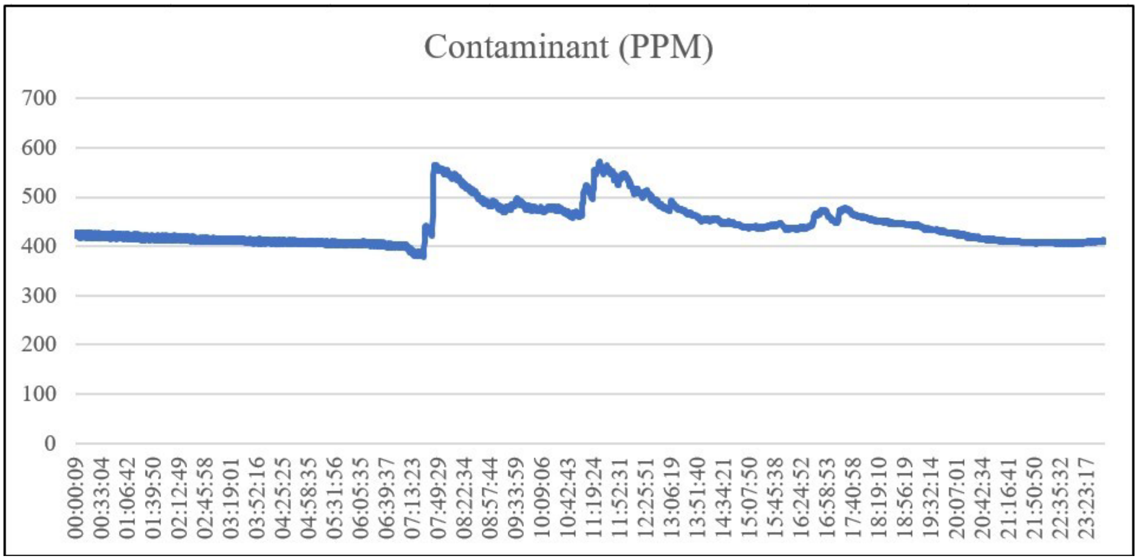

Figure 6. PPM sampled during a day.

6. Conclusion

Supervisors and managers in laboratories need an inexpensive, reliable, and affordable data acquisition system for air quality detection and monitoring. Existing data acquisition systems are based on licensed and cabled software, which are expensive and not easily accessible. They are either continuously connected to the network or manually controlled. Some wireless data acquisition systems exist, but they rely on license-based software and cloud services. There are very few wireless data acquisition systems using freely available software, which monitor and record fewer parameters at a very high cost. These problems can be eliminated using the proposed data acquisition system based on the Internet of Things (IoT). The proposed data acquisition system is based on open access software and cloud service. This paper presents a design of a cost-effective data acquisition system to collect operational data from the air quality monitoring system for evaluation purposes with ubiquitous access. The test results revealed that the suggested data acquisition system is appropriate, reliable, cost-effective, and suitable for harsh outdoor conditions for monitoring and collecting operational information of the system. This system used provides a more affordable method for sensing and monitoring systems in the field of domestic and industrial standards to upgrade the IoT. The following conclusions have been drawn.

- The proposed data acquisition system provides a cost-effective method for sensing and monitoring air quality system for laboratory personnel.
- The proposed data acquisition system can be controlled (ON/OFF) by using the Wi-Fi enabled switch according to the requirement. In this way, we can not only save the lifetime of the sensors.

7. References

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Acknowledgements

- PETROPAR S.A.
- Universidad del Cono Sur de las Américas
- Universidad Politécnica y Artística del Paraguay
- Dr. Jorge H. Kurita

Biographies

Nicolas Ferreira is an undergraduate student at the Mechatronics Department in Universidad del Cono Sur de las Americas. He has worked as a research assistant for 3K Engineering consulting firm in Asuncion, Paraguay.
His skills in the use of simulation software were useful during his internship at the Paraguay Space Agency.

Matías Sánchez is an electronics technician graduated from the Centro Tecnológico de Promoción Profesional Paraguay Japón CTFFP-PJ and is currently an electrical engineering student at Universidad Politécnica y Artística del Paraguay
He works in a private company in the technology sector and has experience in hardware and software development.

Walter Lopéz is a chemical engineer PETROPAR. He has a Post-Graduate Degree from the "Instituto Argentino de Seguridad". From 2000 to 2005, Mr. Lopéz started working as an intern at PETROPAR in 2000 until now he has been appointed Product Control Manager.