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Comparison of Air Quality in Real Time for Urban and Rural Regions through IoT Systems

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Abstract

Air pollution is a problem that affects everyone in the world, it is estimated that close to 93% of children breathe air so polluted that it can generate chronic diseases, the development of risk management models focused on knowledge through Information, data and technological architectures improve the analysis of threats, vulnerabilities, risk calculation and their evaluation to strengthen decision-making, the implemented early warning system, analyze different conditions through the comparative study of temperature and humidity variables. relative, ultraviolet index and air quality in cities with high pollution of the Andean region of the country of Colombia, giving as results the air pollution values of the three regions, determining that not only large cities have high degrees of pollution, but not that rural regions are also presented with excessively high values..

Keywords - Air quality, Monitoring, Temperature, IoT

I. INTRODUCTION

For more than five decades, given the impact and damage generated by disasters [1] associated with phenomena of natural origin [2], socio-natural, technological and unintentional human has begun to have relevance [3] and to be on the public agenda the relevance of the management [4], monitoring and control of risk situations and latent threats, at the international level the promotion of the use of Early Warning Systems-EWS, began in 1960 when the United Nations (UN) began to adopt measures due to the increase in the meteorological and hydrological threats generated by climate change, impacting the health and growth of children who breathe air so polluted where about 93% under 15 years of age approximately 1.8 billion are in serious danger[5].

Starting in the 1960s, international networks for forecasting and alerting different natural phenomena were created and Hydrometeorological monitoring networks began to be implemented within the framework of the agreements signed by the World Meteorological Organization (WMO) [6], subsequently through UN resolution 2717 of 1970 [7] The need to develop these EWS was raised, and in 1994, within the framework of the United Nations International Conference for Natural Disaster Reduction, guidelines for the prevention, preparation and mitigation of natural disasters were established in the XXI century. Likewise, during the World Conference on Disaster Reduction, held in 2005, an action plan known as the Hyogo Framework for Action was established, which establishes the priorities for risk management. [6].

Therefore, risk management models have been developed [7][8], where they mainly focus on the knowledge of risk [9], [10], for this reason the development of information, data and technological architectures [11] allow the formalization of the use of technologies through Early Warning Systems -EWS- for the knowledge of risk through the analysis of threats, vulnerabilities, risk calculation and its evaluation to strengthen decision-making, the general process of management of the risk is described by three processes fig 1, this research focused on the knowledge of the risk of contamination[12] from air [13] In three cities of the Andean region of Colombia, the elements of risk knowledge taken into account were hazard analysis, vulnerability analysis, risk calculation and risk assessment.

Fig. 1: Risk management processes based on [14]

The EWS are used in the risk knowledge process and are defined as the set of tools, control devices, with technological instruments that allow the actors to know timely information, aimed at facilitating decision-making to avoid or mitigate risk [6]. Basically what has been sought is to save lives, reduce and reduce the losses of social, economic and environmental resources [15], therefore, any development that is advanced in the matter of Early Warning Systems is relevant and timely [15], these systems have evolved as science and technology evolve, according to Basher [16], Four stages can be identified, the first is the pre-scientific systems, which are based on the first observations on simple phenomena such as the shape of clouds, the state of the ocean or the visibility of stars, the second is the warning systems "ad hoc" early warning systems, which are specific systems developed at the initiative of scientists or people interested in the risk issue, the third stage is the early warning systems developed by meteorological services, which imply an organized, linear and unidirectional delivery of the products of user alerting by experts and the fourth stage is the

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comprehensive early warning system, which links all the elements necessary for early warning and effective response, and includes the role of the human element of the system and risk management.

Business architecture [17] For the knowledge of the risk, fig 2 contemplates in its different services elements of the alert systems with different subsystems [18], as alert, consisting of predictions and monitoring [19] of the dangers at the national level [20] and international [13], which produces scientific information that is transmitted to the national authorities in charge of disasters, the risk information subsystem, which allows generating the risk scenario and identifying potential impacts, as well as vulnerable groups and sectors that may be affected by the disaster, the communication subsystem, whose objective is to communicate timely information about the danger, with emphasis on vulnerable groups [6] and taking into account mitigation measures, potential risk scenarios and preparedness strategies. The preparedness subsystem, through which strategies and actions are developed to reduce the damage generated by the disaster.

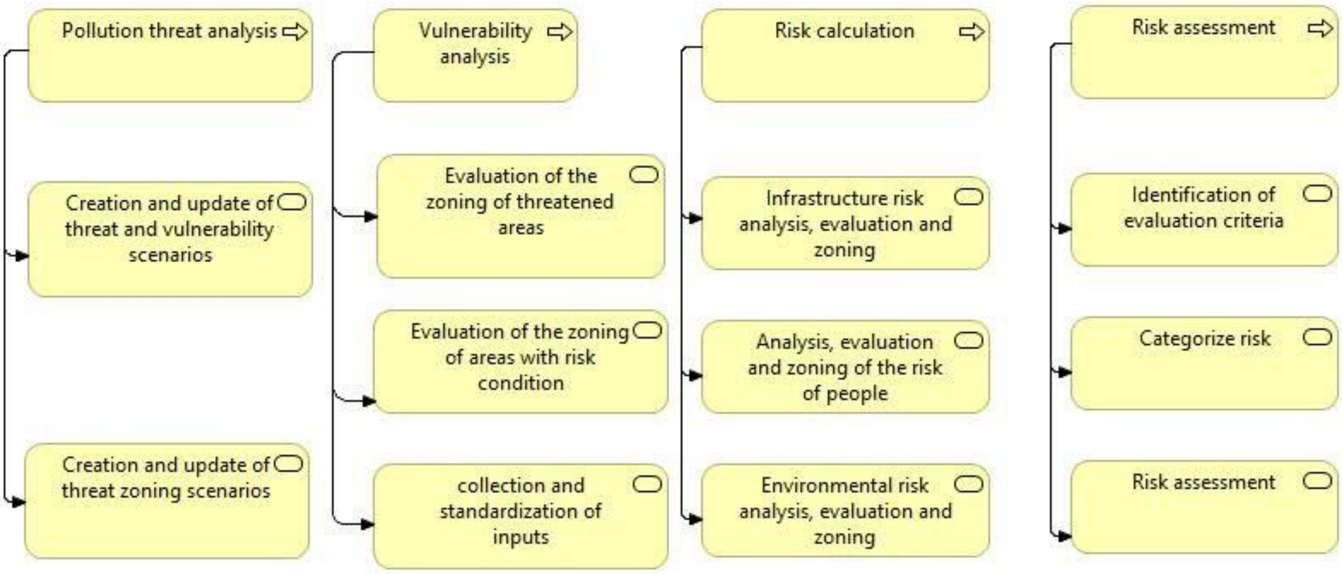

Fig. 2: Description of risk awareness processes.

Taking into account the above, this research set the objective of designing and implementing a low-cost hardware device as a prototype to monitor environmental variables in an integrated way, contributing positively to decision-making to manage early warnings in the city of Bogotá, likewise to carry out verification tests that would allow comparing the values obtained in the cities of Medellín and the province of Ubaté, the document is structured in four parts, the first part describes the research problem and a brief state of the art, in a second part the design and implementation of the model with each of its parts, in the third part the case study and its results are exposed and finally the conclusions obtained.

II. MATERIALS AND METHODS

The design of the IoT architecture is based on the acquisition of data through sensors [21], which is carried out by a development card and transmitted to a service platform where it is stored in a database and from there it is taken to make the information presentation, the selected IoT software platform was ThingSpeak Tm which receives the data, saves, processes, analyzes and presents, this allows the threat scenario to be updated by improving the risk knowledge information, fig 3 presents the architecture.

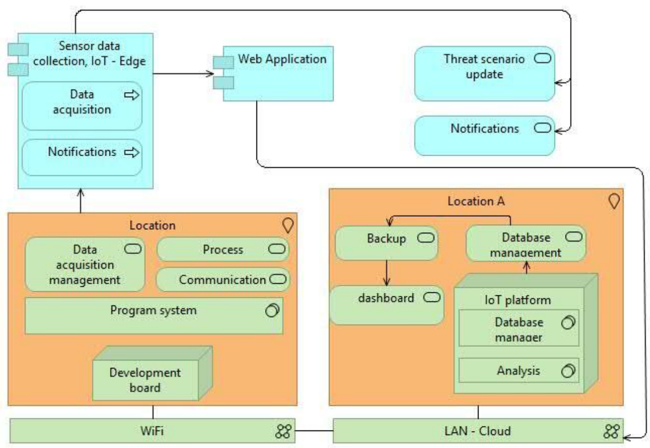

Fig. 3: Information, data and technology architecture based on Togaf for air pollution

The WSN is composed of three sensors interconnected table 1 by a data acquisition that was carried out with an Arduino Mega card that a sampling time of 112 micro seconds, which is equivalent to a sampling frequency of 8.928 kHz, the humidity variable and temperature have a slow response time, two sensors were used to have a comparative measurement of the same variable at a time of 2 seconds, which guarantees the sampling frequency of the development card and the existence of changes in the signal, the Humidity refers to the presence of water vapor in the environment, temperature indicates the amount of heat that the air has at a specific time in a given space, air quality also shows a slow change because it is an accumulated value in the processes for which a dual MQ-135 sensor was used, this detects concentrations of carbon dioxide, ammonia, benzene in a range of 10- 10000ppm, the air quality shows how well Contaminated is this in a certain period of time and place and what could be the effects on the health of living beings, an ultraviolet light (UV) sensor was also used, with an analog UV signal (mW / cm2) that depends of the amount of UV light that it detects, it detects light in the UV-B spectrum as

UV-A, UV radiation that refers to electromagnetic radiation coming from the sun and that its wavelength is in the range of 400 nm and 15 nm approximately. For the IUV and ICA, the WHO determined a color protocol depending on the intensity: green color, low level; yellow, medium; orange, tall; red, very high; and purple, extreme.

Table 1. Sensor Specifications

Sensor	Measurement range	Voltage	Precision
Dht22	-40°C~125°C 0%RH~100%RH	5V	2%~5%
Mq 135	10ppm~1000ppm	5V	+/- 0.1%
UV ML8511	0-1024mV - 280-390nm light	-0.3 to +4.6V	+/- 1%

When the WSN collects the information, it transmits it through an ESP8266 module to an available communications node with output capacity to the network, this is bred through the TCP / IP protocol stack, which ensures the information, encrypts it and transmits, in the process described in fig 4, the information is received by an IoT platform that has storage and presentation services, to carry out another type of analysis the information was downloaded for subsequent analysis. The main function of the WSN network for IoT is to collect the information from the sensors fig 4 defining the variables, which are sent every time there are changes in the signal to avoid overloading the network, although the optimization of the network is small signals. resources are vital.

III. RESULTS AND ANALYSIS

The experimental phase of the research was carried out in the country of Colombia in South America in three different regions that are characterized by high levels of pollution, the first city was Bogotá, which is the capital of the country, it is located at an altitude above sea level of 2.600 mt, an average temperature and humidity of 18 ° C and 75% respectively, it is an industrial city focused on production; The second city is Medellín, it is located at an altitude of 1495 meters above sea level, a temperature of 20 ° C and 83% average humidity, it is the second most important city after the capital, its economy is also of production based on textiles, substances and chemical products, food, and beverages, the third city is the province of Ubaté is located at an altitude of 2,556 meters above sea level, an average temperature and humidity of 11 ° C and 93% respectively, unlike the previous cities, Ubaté has a smaller population and the size of the city is considerably smaller, economically it focuses on agriculture, livestock, milk production, the latter being considered the one with the greatest impact.

A. First city Bogotá case

In the case of Bogotá fig 5, the variation in air quality during the day is observed, having a peak at 8:00 p.m., while humidity

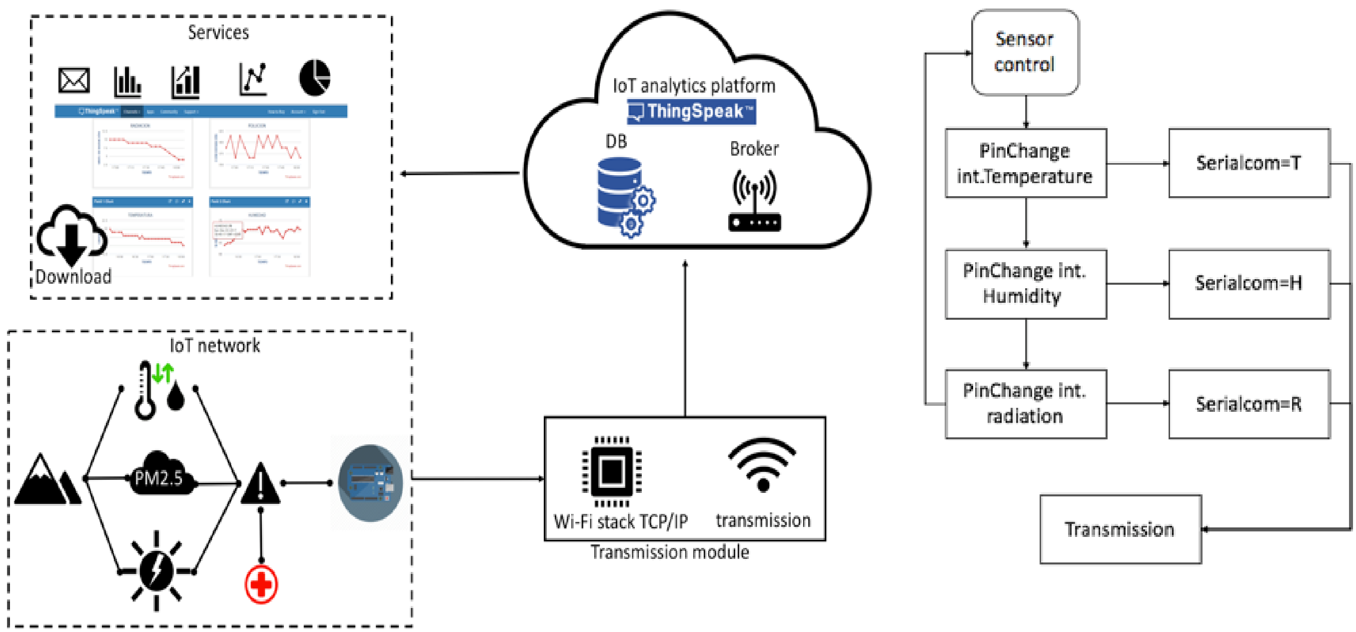

Fig. 4: IoT architecture for air pollution, leading research group.

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behaves contrary to temperature, increasing with the course of the day appreciates that in Bogotá the humidity-temperature and humidity-UV index correlations are inverse, strong and almost perfect, while the temperature-UV index correlation is direct, strong and almost perfect fig 5.

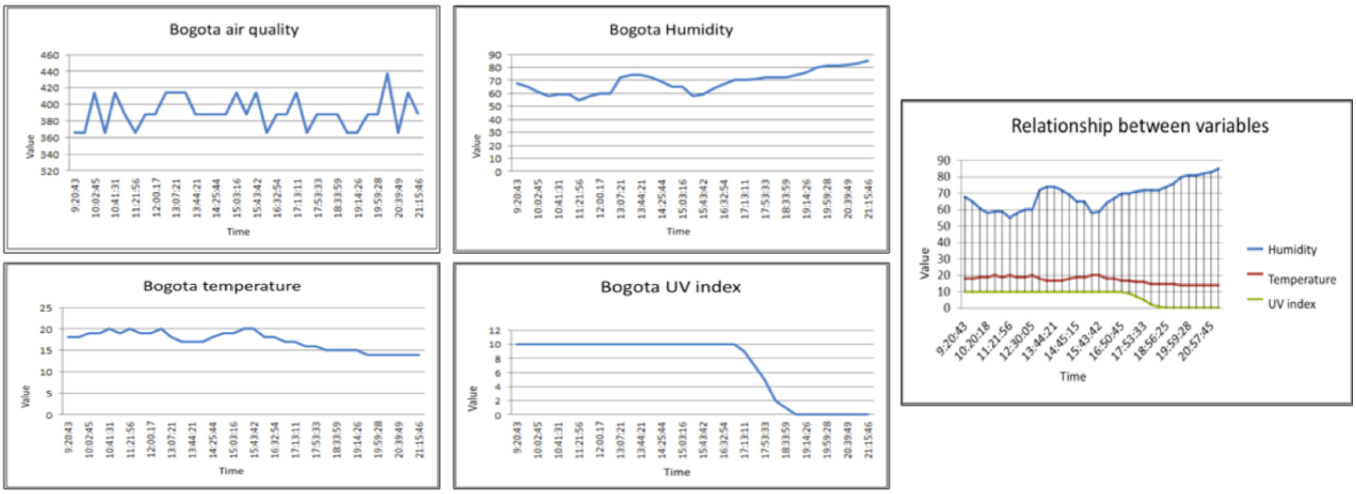

Fig. 5: Relationship a comparison of variables in the city of Bogotá.

B. Case Second City Medellín

For the realization of the graphs corresponding to the measurements in Medellín, it was taken into account that the contamination window occurs between 10:30 and 19:00, since according to what was stated by the SIATA director, it is from This time when the increase in pollution in the city is most noticeable, a phenomenon generated by Thermal Inversion, which prevents the exit of pollutants emitted by fixed and mobile sources to the upper part of the atmosphere. Also due to this Thermal Investment, in very hot seasons the radiation is very high in some areas of the city.

It should be noted that, although the correlation between the variables is low (except for the one between humidity and temperature) the values remain very high, for example, the values of air quality, humidity, temperature and radiation were 666, 67, 23 and 10 respectively, in fig 6 the monitoring of air quality is observed, relative humidity of the air, temperature and UV index, the almost perfect inverse correlation between humidity and temperature is observed, whereas the humidity decreases, the temperature increases while the UV index remains unchanged.

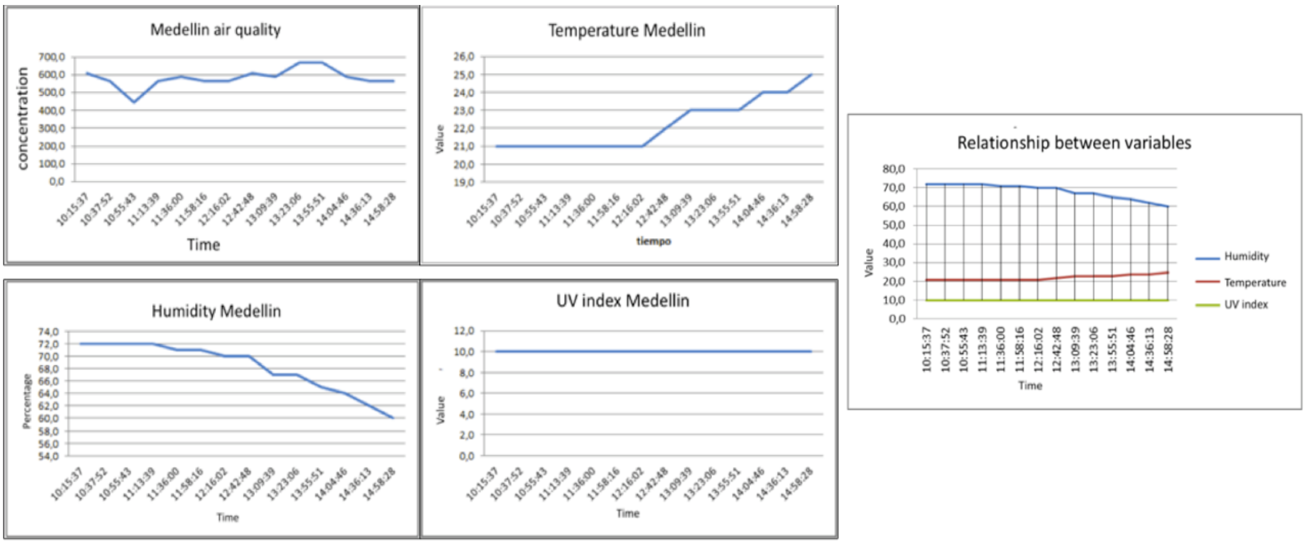

Fig. 6: Relationship a comparison of variables in the city of Medellín.

C. Case Third Ubate City

Although the humidity, temperature and UV index forecasts are found on the internet, which are very similar to those thrown by the device, it is not possible to access real-time information on the air quality of the Ubaté Valley, which is why made a small comparison with the values collected on three dates, contrary to what was thought, the values obtained for air quality were very different from those obtained in the measurements of Bogotá and Medellín, this because the town of Ubaté is located in an area that occupies the fourth position within the most contaminated populations of the department [22].

The measurements were taken in the month of December and January at different times where a high percentage was observed in the blue band corresponding to 6 am, which varies in a similar way during the morning fig 7, in the pink band the enlargement of the variation corresponding to afternoon hours and at night, the green band increases the levels, fig 8 shows the very slight inverse correlation between humidity and temperature, a strong direct relationship between temperature and UV index, whereas increasing temperature also increases the UV index, and a slight inverse relationship between humidity and UV index whereas the humidity decreases, the UV index increases. In the three cities the data was taken and compared against nearby stations of IDEAM, in fig 9 the comparison is observed, likewise it was compared for the case of Bogotá in air quality with the environmental observatory having a concentration value PM10 47µg/m³ considered as good and in the city of Medellín the air quality was compared with the SIATA data, obtaining a moderate rating and a very high UV index.

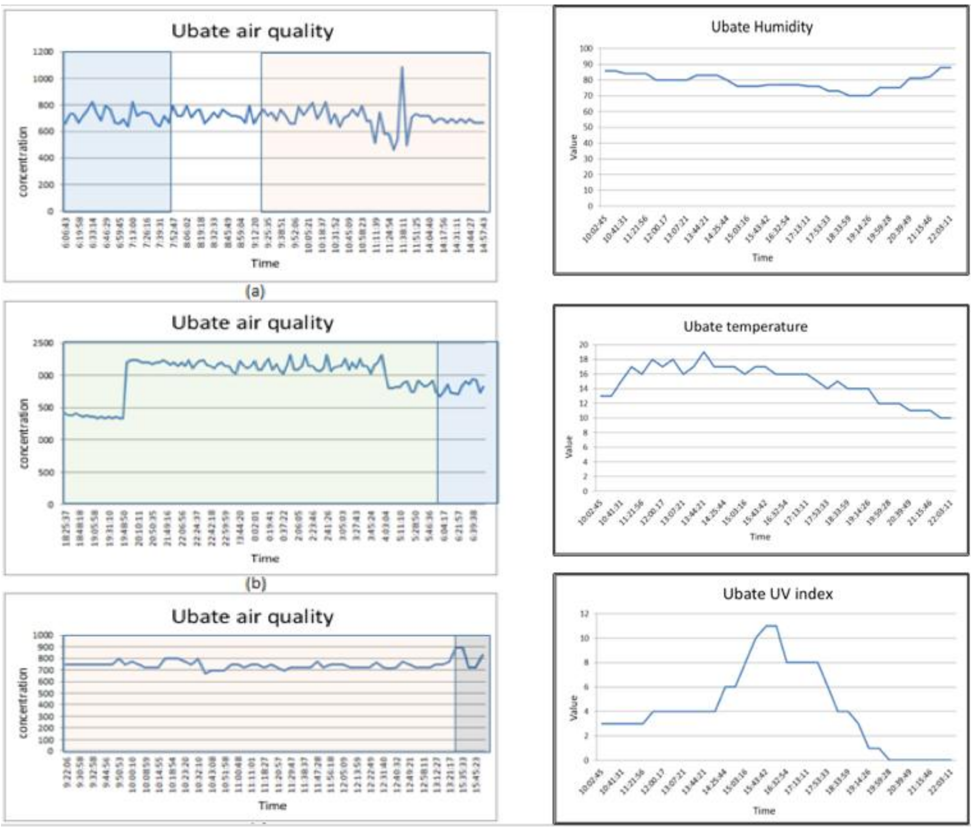

Fig. 7: Relationship of variables in the city of Ubaté.

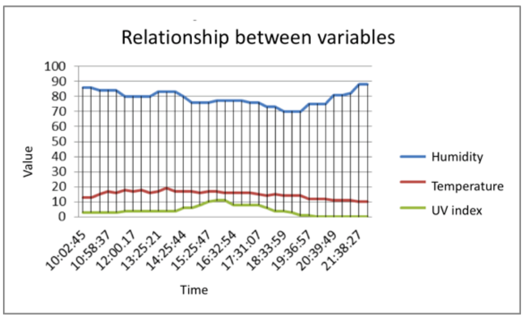

Fig. 8: Comparison of variables in the city of Ubaté.

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D. Comparison Between Cities

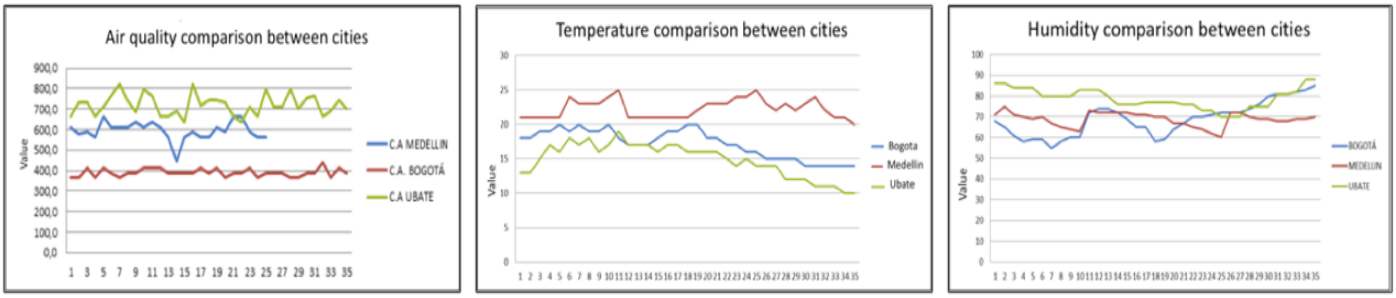

Fig. 9: Comparison of variables between cities

IV. CONCLUSION

After performing several measurements it was possible to establish that the data provided by the device are very exact (although the device still needs to be adjusted to the WHO AC values since those obtained are in ppm), and with its low cost (about US 200 approximately, including the casing) makes it possible to replicate it message to take specific data collections in different places and thus establish a monitoring network for a whole city in which the institutions in charge and / or the common citizen can access the data. of your interest in real time. In addition, when using the free access IoT platform (ThingSpeak), it allows us to first visualize, graph the information from up to 8 different sensors simultaneously for each device and configure twitter alerts if required; second, store up to 3,000,000 data for two years to provide baseline information and most importantly, generate historical data and third, perform online analysis and processing of data as it occurs.

From the graphs it can be inferred that, in cold climates such as Bogotá and Ubaté, as night falls the humidity increases while the temperature decreases, otherwise than what happens in Medellín, whereas the hours pass, the humidity decreases as the temperature increases.

Although the low presence of clouds increases the intensity of UV radiation, when it is cloudy or there is mist, high values can also be obtained due to scattering, which can produce the same effect as reflection or albedo on different surfaces such as cement, water or asphalt.

One of the reasons that affect the quality of the air is the geographical characteristics which, in transitional meteorological conditions between the dry season and the rainy season, cause thick low-altitude clouds to exist, which prevents the entry of solar radiation until the surface or the exit of existing radiation, generating an accumulation of pollutants in the lower part of the atmosphere, which are emitted by fixed and mobile sources, which generates that there is no removal of particulate material by wind action due to the height of the mountains, this case occurs in the Bora Valley and in Bogotá which is a plain bordered on the eastern side by mountains.

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