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Correlations of Air VOC Measurements of the City of Bucaramanga Colombia, By Means of an Electronic Device

Walter Pardavé[1], Yenni Santamaría[2], Luis Reina[3]
[1]*(Environmental Group of Applied Research GAIA, UDES, Colombia)*
[2]*(Department of Metallurgical Engineer, Industrial University from Santander, UIS, Colombia)*
[3]*(Research Group on New Technologies UDES, Colombia)*
Corresponding Author: Walter Pardavé

Abstract: *This Research paper presents the results of the first phase of a study dealing with estimation of atmospheric pollutants, volatile organic compounds (VOC) mainly from mobile sources in the urban area of the area Metropolitan of Bucaramanga, formed by the municipality of Girón, Floridablanca, Piedecuesta and Bucaramanga with a population of more than one million inhabitants. The Automotive Park of the study area has had an exponential increase that has December 2016 reports 646,848 vehicles, which have significantly increased emissions of gases and particulate matter, including VOC. At The moment there is no record or studies of quantity, concentration, effects or impacts of VOC by mobile sources in the metropolitan area of Bucaramanga.*

Using an electronic device that registers total VOC values at five strategic points, records have been taken in ppb, finding an average of 96.85, and as the area with the highest concentration is the center (Carrera 15 with street 36) with a value of 145.5 ppb Coinciding with the city's largest land traffic area. In A second phase will be sampling of the VOC best known for its effects on human health and these data will be compared with estimates of AERMOD software.

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I. Introduction

In Colombia, air quality represents one of the biggest challenges the country has to face in terms of pollution; this is why the deterioration of air quality has caused the health of Colombians to be compromised especially with the proliferation of respiratory Diseases.

According to the Santander Public Health Observatory (OSPS), in Bucaramanga and the metropolitan area, the deterioration in air quality and the increase in atmospheric pollution are mainly due to the emissions of gases from vehicles that use fuels Fossils, or diesel, in the case of buses and heavy-duty vehicles. Cars pollute more than the industry because in the locality there are only small and medium-sized companies whose environmental impact is not enough to be major.

The growth of the automotive park is also a transcendental factor in analyzing air pollution. Figures presented by the Traffic Direction of Bucaramanga (DTB) show that the municipality had 76,576 cars and 24,503 motorcycles registered at December 31, 2011.

Figures to December 2016 show a motor park 646,848 vehicles of which 378,677 motorcycles (59%), 146,591 vehicles (23%) And the rest between trucks and other heavy vehicles (18%). The conflicts generated by the increase of vehicles in the area have to do with the frequent trancones in which the drivers are forced to brake and start consecutively, being this an action that generates more pollution than the one that produces a Car that runs at 60 miles an hour without stopping.

So far there are no data of VOC in the air of Bucaramanga, therefore this work aims to cover this lack of information to know the real impact on the human health of people of the cityof Bucaramanga and areas of risk, for this by using in a first phase an Electronic device design for VOC registration, and later in another phase will perform a simulation with the Aermod software and the respective model validation with direct measurements of VOC.

II. Material And Methods

Conventional pollutants in the environment are routinely measured in air quality monitoring networks and there are very extensive databases and, in general, good quality, but for certain unconventional atmospheric pollutants such as Volatile Organic Compounds (VOCS), the data are often inconsistent and not extensive (in space and time). In accordance with widely accepted criteria, in the term COV are grouped compounds with carbon present in the atmosphere that have a vapour pressure higher than 0.01 kPa at 293.15 K, except for the methane that by its special characteristics is treated separately. VOCS are composed of a complex mixture of low molecular weight compounds, with a number of carbon atoms normally between 2 and 12[1].

The availability of VOC ambient concentration data is essential for any risk assessment, as ultimately, the assessment of the human health risks derived from air pollution requires information on Levels of exposure of the population to the different pollutants, the number of people exposed (including risk groups) and the knowledge of the quantitative relationships between exposure and health effects[2].

In Urban Atmospheres the main anthropogenic sources of VOC, although not the only ones, are the mobile sources. Of these, the emissions due to the road traffic, mainly emissions by the exhaust pipe and evaporation losses, are highlighted, in addition to the own emissions of the liquid petrol which are present in the ambient air of practically any urban area[3,4]. These emissions depend not only on the type of engine (explosion, diesel, etc.), but also on the operating system itself, the fuel they use and the age of the vehicle. Even the composition of the gasoline varies depending on the geographical region, the season of the year, octane requirements or the source of crude of which it proceeds. Fugitive emissions from the transport and distribution of fuels (petrol, gas oils and LPG), emissions from natural gas and the use of solvents are Also of particular importance in urban areas. The realization of the measures is not simple task given the large number of compounds and the low levels of concentration in which many of them are in ambient air (PPBV-PPTV). Analytical instrumentation Is required with multicomponent capacity and high sensitivity and resolution The most commonly used techniques for The analysis of VOC's in ambient air, are currently based on gas chromatography, mainly because it is instrumentation Highly specialized analytical, with multicomponent capacity, high sensitivity and resolution. The measures are not simple because of the difficulty of speciation complex VOC mixtures, such as those present in ambient air, which come from various anthropogenic and natural emission sources, and their atmospheric oxidation products. It is Also necessary to take into account the large number of compounds and the low levels of concentration in which many of them are in ambient air [5].

Many VOCS from Anthropogenic and biogenic sources (See Table 1 and 2) participate in atmospheric chemical reactions which, together with nitrogen oxides and the presence of solar radiation, are the main precursors of tropospححericic ozone and other photochemical oxidants. It is Necessary to take into account the qualitative composition of the mixture of organic compounds in the atmosphere, since some VOCS react more effectively than others, that is to say that they have among themselves different capacity of generation of photochemical oxidants, as a consequence of its different reactivates and structure. Among them ozone is usually considered the most important because of the high concentrations of the same that can be achieved (up to several hundred ppb) and the important documented effects on human health, plants and materials.

Table no 1: List of some of the 62 COV identified and quantified.

PLOT COLUMN		**BP1 COLUMN**	
Peak number	**Compuesto**	**Peak Number**	**Compound**
1	Ethane	28	n-Hexane
2	Ethylene	29	Methyl Cycle Pentane
3	Propane	30	2,4-Dymetil Pentane
4	Propylene	31	Benzene
5	i-Butane	32	Cycle Hexane
6	n-Butane	33	2-Methil Hexane
7	Acetylene	34	2,3-Dymetil Pentane
8	trans-2-Butene	35	3-Methyl Pentane
9	1-Butene	36	Trichloroethylene
10	i-Butylene	37	1-Heptene
11	cis-2-Butylene	38	2,2,4-Trimetyl Pentane
12	Cycle Pentane	39	n-Heptane
13	i-Pentane	40	Methyl Cycle Hexane

Table no 2: List of mean of the toxic COV identified

1,3-butadiene	2,2,4-trimetylpentane	m&p-xylene
n-hexane	Toluene	styrene
benzene	Tetrachloroethane	o-xylene
Trichloroethane	Ethylbenzene	Isopropyl Benzene

Figure 1, 2, 3 and 4 shows an electronic VOC measurement device in air, based on a sensor created by Dean Miller, which was taken to a box with temperature display, CO2 concentration and VOC concentration in ppb.

Figure no 1: Diagram of sensor Blocks in the air

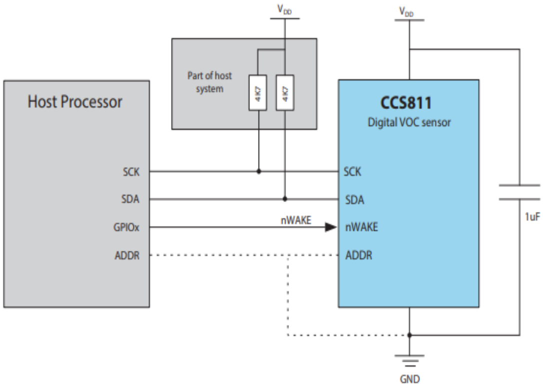


Figure no 2: Connection to the sensor

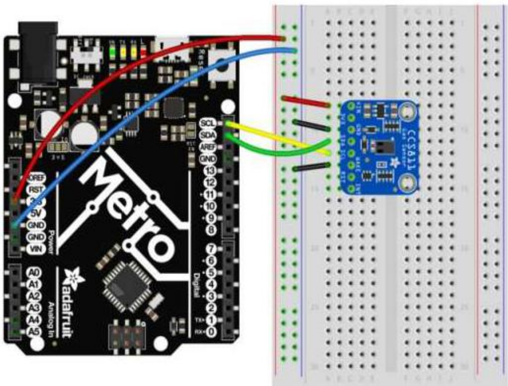


Figure no 3: Box Construction

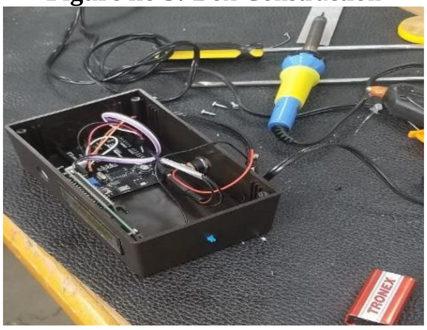
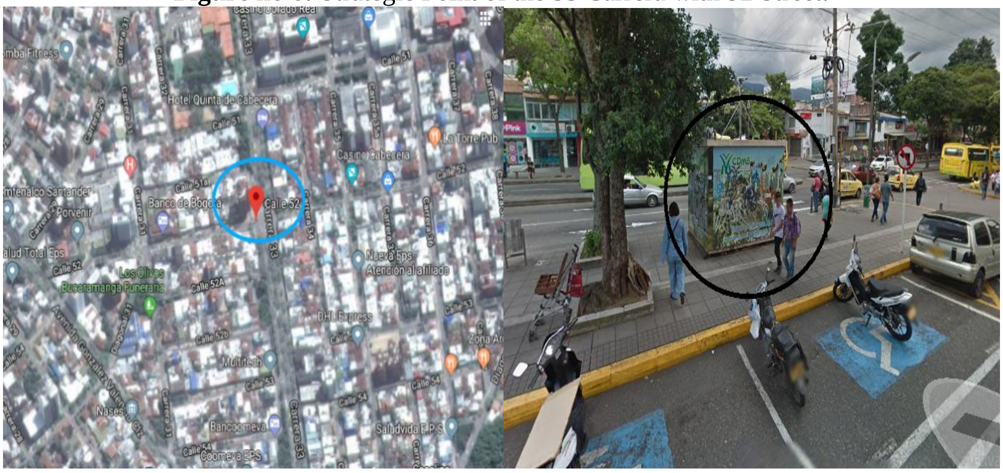


Figure no 4: Box Viewer Device

Figure 6 shows the field data-taking work based on 8-hour measurements at each point taken into account. These measurements were made every 5 minutes and then the value was averaged every hour, 6 values were recorded for each day of taking.

Figure no 5: Data Taking at the strategic points of the city of Bucaramanga AMB

Figure no 6: Strategic Point of the 33 Carrera with 52 Street.



Sampling and data taking were carried out at five strategic points in the metropolitan area of Bucaramanga, which comprises the municipalities of Bucaramanga, Floridablanca, Piedecuesta and Girón, which in total have a population that exceeds one million inhabitants. Figure 6 presents the first point located at the intersection of the Carrera 33 and 52 street in the municipality of Bucaramanga, a place where automotive traffic, commercial area and is the beginning of the western escarpment of the green lung of the city**.**

Table no 3. VOC and temperature Measurements every half hour in a range of 8 hours

Nª	VOC (ppb)	T(ªC)
1	73	25.1
2	86	25
3	31	24.2
4	288	24.1
5	49	23.4
6	202	23.6
7	133	23.6
8	192	23.1
9	201	22
10	146	22.1
11	130	23.1
12	148	22.1
13	167	22.2
14	160	22.8
15	194	22.9
16	129	22.5

On the 33 Race with 52 Street the measured temperature in an interval of 8 hours present an overage of 23.2375 °C with a Standard Deviation of 0.98718

Figure 7 presents the second strategic point of data-taking of VOC, located at the Aurelio Martínez School in the area of Ciudadela Real de Minas in the municipality of Bucaramanga.

Figure no 7: Strategic Point of the Ciudadela de minas

Table no 4. VOC and temperature Measurements every half hour in a range of 8 hours

Nª	VOC (ppb)	T(ªC)
1	11	24.3
2	21	24
3	8	24.2
4	81	24.1
5	117	23.7
6	48	23.6
7	206	23.7
8	113	23.8
9	58	22.9
10	19	22.8
11	51	23.1
12	12	22.5
13	61	22.1
14	63	22.1
15	40	21.9
16	86	22.1

On the Ciudadela de Minas the measured temperature in an interval of 8 hours present a media of23,1813°C with a Standard Deviation of 0,8463

The strategic Point Number three, is located in the Hospital of the North, zone close to suburbs and also of industrial zones of the municipality of Bucaramanga. (See Figure 8)

Point four corresponds to the registration station on 34 Street with Carrera 15, the neuralgic point of the municipality of Bucaramanga. (See Figure 10).

Figure no 8: Registration Point of the North Hospital, Bucaramanga

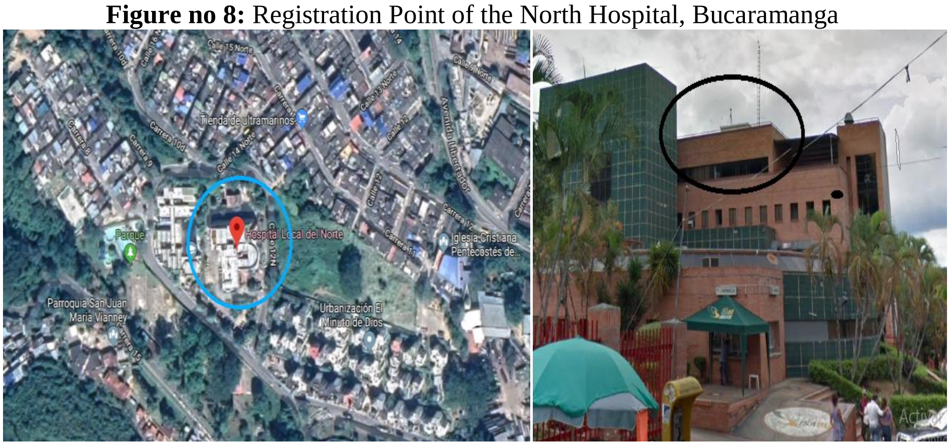


Table no 5. VOC and temperature Measurements every half hour in a range of 8 hours

Time	VOC (ppb)	T(ªC)
1	1	21.2
2	8	22.1
3	15	22.2
4	11	22.1
5	33	23.1
6	54	23.4
7	27	23.2
8	91	23.5
9	135	22.1
10	177	22.1
11	262	21.1
12	75	21.5
13	78	22.1
14	61	22.3
15	84	22.1
16	72	21.8

The average value from Temperature in North Hospital was 21,2313 °C whit a Standard Deviation of 0,71528.

Figure no 9: 34 Street sampling Point with 15 Carrera, Bucaramanga

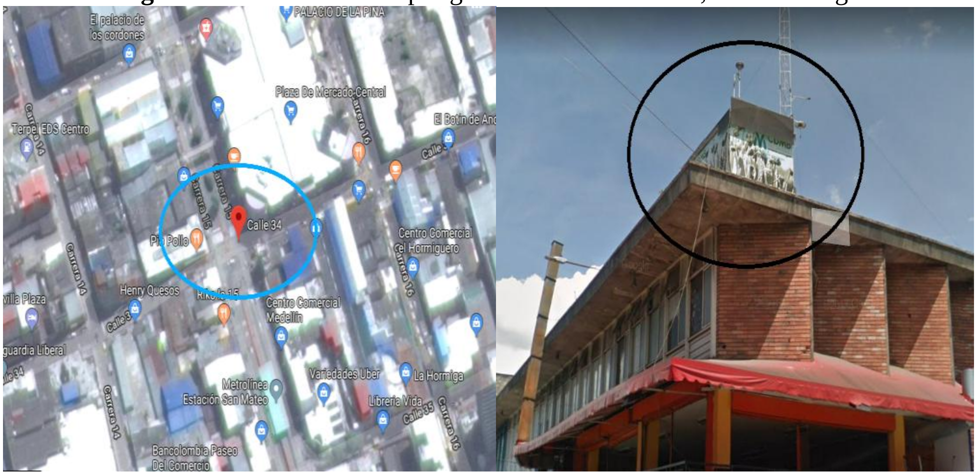


Table no 6. VOC and temperature Measurements every half hour in a range of 8 hours

Nª	VOC (ppb)	T(ªC)
1	98	24.5
2	111	25.1
3	223	25.2
4	85	25.1
5	172	25.1
6	39	25.4
7	88	25.2
8	109	24.5
9	54	24.1
10	99	24.4
11	118	24.1
12	159	23.5
13	112	23.1
14	114	23.3
15	129	23.1
16	103	23.8

On 34 Street sampling Point with 15 Carrera, the overage temperature value was 24,3438 °C , whit a standard deviation from 0,80247.

Figure 10 shows the strategic point five, given in the ring road specifically, place of confluence of the municipalities of Girón, Floridablanca and Piedecuesta.

Figure no 10: Anillo vial Registration Point

Table no 7. VOC and temperature Measurements every half hour in a range of 8 hours

Nª	VOC (ppb)	T(ªC)
1	90	25.6
2	6	26.1
3	27	26.3
4	92	27.1
5	69	27
6	112	26.8
7	79	26.7
8	93	27.3
9	207	26.4
10	121	26.7
11	112	27.1
12	53	26.9
13	87	26.4
14	90	26.7
15	56	26.3
16	112	25.9

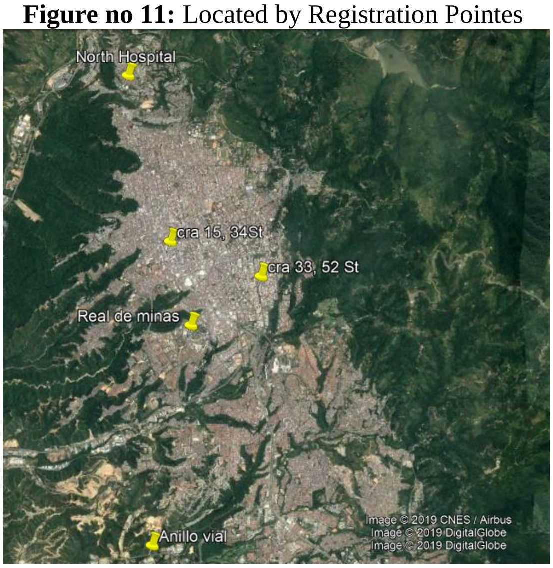
On Anillo vial, the overage temperature value was 26,5812 °C, whit a standard deviation from 0,469.

Statistical analysis

Data was analyzed using Statgraphics

In Figure 11, you can observe the Registration pointes location on the city of Bucaramanga to the present study.

Figure no 11: Located by Registration Pointes



Taken from Google Earth

Figure no 12: Comparative of VOCs Values from Registration Pointes

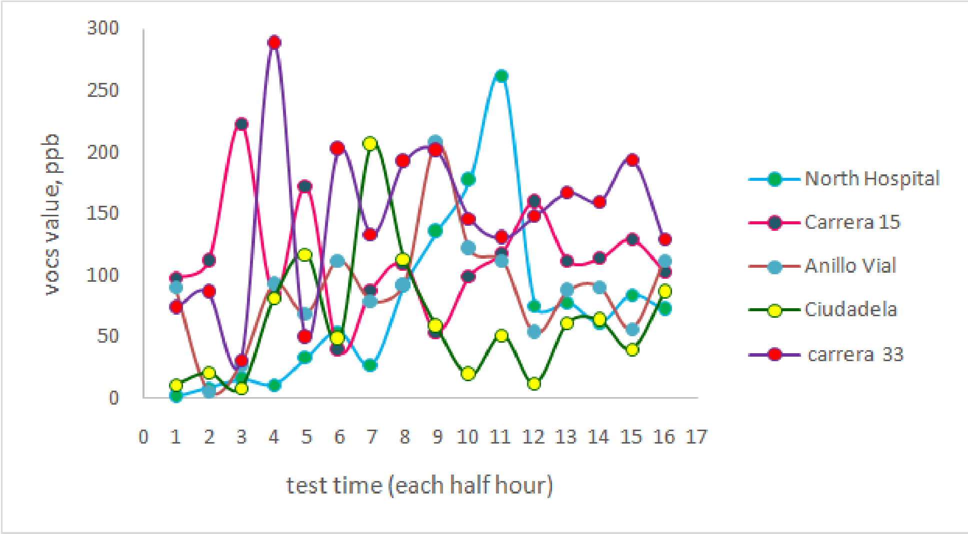
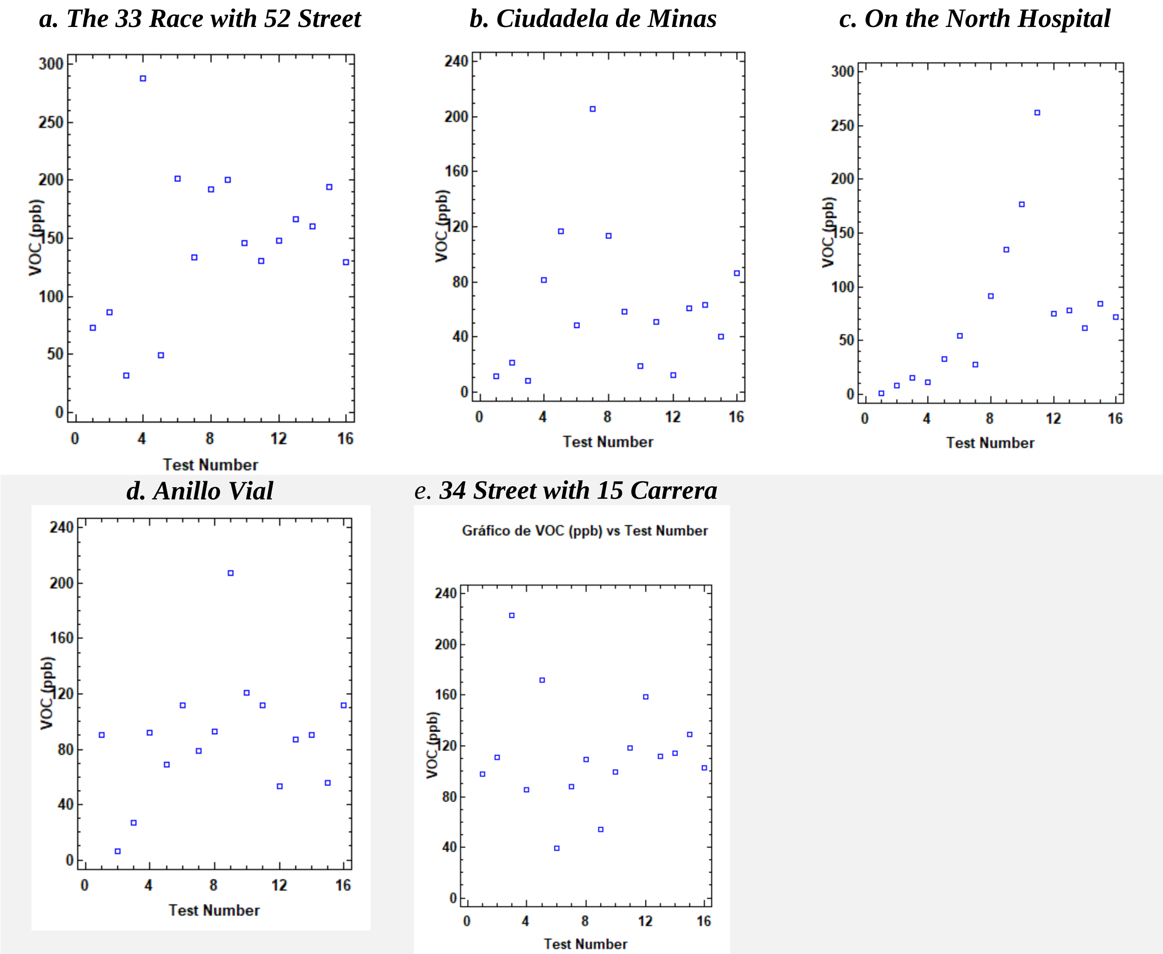


Figure no 11: Dispersion of VOCs Values from Registration Pointes



Ministry of environment, housing and territorial development resolution number (601) 04 April 2006 by which the Standard of Air Quality or Level of Inmision is established, for the whole national territory under conditions of reference.

Table no 8. Permissible limits to Colombian lawyer.

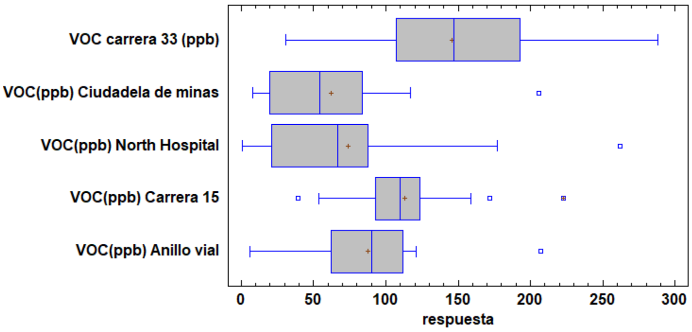
Contaminants	ppm permissible
Etil mercaptano (C_2H_5SH)	0.0002
Etil acrilato ($C_5H_8O_2$)	0.00047
Estireno (C_8H_8)	0.047
Monometil amina (CH_5N)	0.021
Metil mercaptano (CH_3SH)	0.002
Nitrobenceno ($C_6H_5NO_2$)	0.0047
Propil mercaptano (C_3H_8S)	0.007
Butil mercaptano ($C4H_{10}S$)	0.0007
Sulfuro de dimetilo (C_2H_6S)	0.002
Sulfuro de hidrógeno (H_2S)	0.005

Table no 7. Statically analyze

Place	Range	Count	VOCs Overage	Coefficient of variation	Standardized bias	Kurtosis
Carrera 33, 53 Street	31.0 to 288.0	16	145,56	44,75%	0,206557	0,3198
Ciudadela de minas	8.0 to 206.0	16	62,18	82,68%	2,4751	2,467
North Hospital	1.0 to 262.0	16	74	93,41%	2,5068	2,169
Carrera 15	39.0 to 223.0	16	113,31	38,72%	1,4067	1,4704
Anillo vial	6.0 to 207.0	16	87,87	51,03%	1,259	2,3011
Total		80	96,58	64,35%	2,7359	0,8072

Note that standardized bias and kurtosis are outside the range of-2 to + 2 for Anillo vial, North Hospital and Ciudadela de minas values, so the normal distribution from VOCs does not apply in these cases.

Figure no 11: Box chart and Whiskers



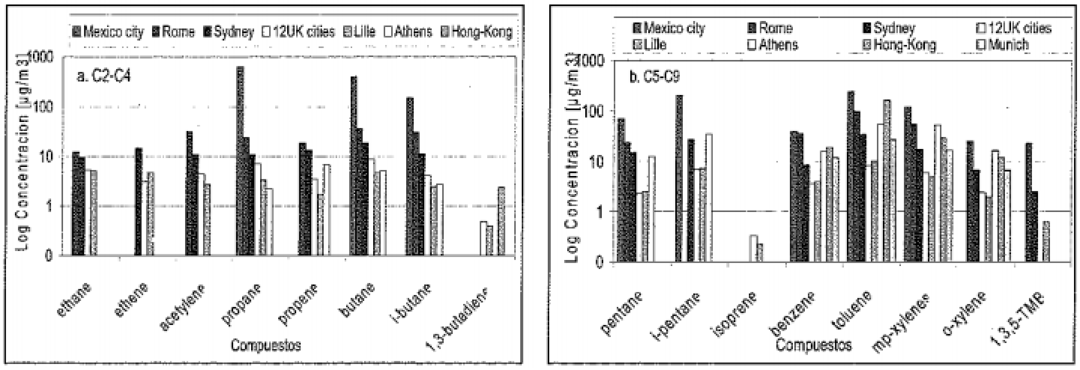
Carrera 33 present the highest values to VOCs particulates, followed by Carrera 15. Observe that these points are located into the city. It cause that the air dispersion to the gases and particulate material was slower because the high building that prevents normal passage of air currents that another points when the environmental conditions makes that COVs will be disperse quickly and and make these not accumulate.

Comparison of VOCS levels in some important cities of the world

An atmosphere of the VOCS levels present in the different cities of the world is shown in Figure 12

According to that study Mexico is the city most affected by the VOCs followed by Rome and Hong Kong. The most abundances compounds are ethane, ethene, acetylene and toluene.[12]

Figure no 12: Comparison of VOC_S levels in some cities of the world



III. Conclusion

Using an electronic device that registers total VOC values from several critical points in Bucaramanga was possible to take the overage values to this Concentration, finding an average of 96.85 ppb, and as the area with the highest concentration is the center (Carrera 15 with street 36) with a value of 145.5 ppb, that highest value was associated with the high traffic in the area.

When comparing these values with some other cities, considering that the measuring devices they use measure each component individually: benzene, etane, propane, etc; At the same time we can guarantee that similar studies have not been done in the City, since the city is not so great, therefore the levels of air pollution are not so high when compared with Mexico for example.

However, considering that the portable device that is used is new in the market, it is recommended to carry out other measurements in places close to factories, industrial zone and parks, to collate the information. In A second phase will be sampling of the VOC best

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