Chapter 8

Air Quality in Urban Areas in Brazilian Midwest

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Additional information is available at the end of the chapter

http://dx.doi.org/10.5772/50373

1. Introduction

The terrestrial atmosphere includes a vast region, mainly dominated by gas that surrounds the planet. One of the most relevant features of the Earth's atmosphere is its selectivity to energy, while remaining transparent to the significant portion of wavelengths sent from the sun, and opaque to others arising from the de-excitation, as heat from the surface. The climate system and the thermal equilibrium is maintained by the transfer of solar energy for the Earth's surface, and from one region to another surface of the planet, in addition to referral to the outer space. This dynamic is intrinsically related to selective qualities present in the architecture and physical chemistry of Earth's Atmosphere.[1-3]

According [1] due to the atmosphere to be in a fluid system, it is capable of supporting a wide range of movements, ranging from a few meters turbulent eddies to the movements of air masses having a size of the planet. This mobility of the fluid system makes the description of complex behavior, she being responsible for the redistribution of mass, energy and other constituents in infinite configurations.

Current knowledge about the characteristics of the atmosphere is derived from several experimental observations. The composition of gases as to its constitution and concentration is essential for sustaining life on the planet, so the oscillation percentage, even of trace gases, can cause damage to populations of living beings or phenomena closed imbalance in the atmosphere.

The variability of meteorological parameters as temperature, wind speed and direction and relative humidity, among others, are closely associated with fluctuations in the concentration of trace constituents. However, the composition of the gaseous atmosphere is substantially constant between the major gas as nitrogen (78%), oxygen (21%) and argon (0.93%). [3,4,5]

A very small extent the composition of atmospheric gases, about 0.07%, is so-called trace gas. Some of these gases due to the action of human means of production, mainly in

urban areas, concentrations higher than those found in remote areas of anthropogenic influence.

A finding in recent decades, due to restrictions imposed by law, is to reduce the rates of pollutant emissions in developed countries. In Germany, pollutants as carbon monoxide, sulfur dioxide and particulate matter, fell sharply, while others, such as nitrogen oxides and volatile organic compounds have undergone modest reductions. According to [6] between 1975 and 1996 emissions of carbon monoxide decreased from more than 16 Mton to negligible values after 1994.

In this manner, there is a close relationship between the level of development of a nation and control pollutant concentrations monitored in regions with large population.

In Brazil, the time series of Air Quality are restricted temporally, that is, there are few cities in the country that maintain monitoring network of air pollutants. The Metropolitan Region of Sao Paulo (MRSP) is one of those few cities which, through the State Company of Environmental Technology and Sanitation (CETESB) since the 1980s has received continuous monitoring of air quality and increasing control and inspection.

2. Air quality in Brazil: Some features

In Air Quality Report of the State of Sao Paulo [7], the decrease in concentration of pollutants in the Greater Sao Paulo, as a result of improvement in the control and supervision, are not evident for all pollutants monitored. Figures 01 and 02 illustrate, respectively, the maximum annual average concentrations of over 10 years of Carbon Monoxide and Ozone in different monitoring stations in the MRSP. In both figures the scales are below the safety limit determined by the National Standards for Air Quality.

In Figure 01 the annual average concentrations of carbon monoxide related to maximum of 8 hours in some regions such as Central and Congonhas, decreased by over 50% in 10 years. The same occurs with less intensity, to the Center of Campinas that, although with a smaller series, the values fluctuate around 2.0 ppmv. However, after 2003, all stations show stabilization of concentrations in a range between 1.0 and 3.0 ppmv.

This, possibly, part of his explanation is related to the implementation of emission control technologies in automotive vehicles in the MRSP. In the early 1980s the estimated emission factor for carbon monoxide, light fleet was 54 g/km in the last year this index is less than 0.5 g/km. [8]

The annual average concentrations of 1-hour maximum ozone, Figure 02, show small displacement amplitude, for most areas, between the years 2000-2003 to 2005-2006. In the first period, the mean concentration varied between 90 and 110 μg/m3 subsequently between 70 and 90 μg/m3. But this does not mean that there is a tendency to decrease. Often, the limits for ozone standards are exceeded in the MRSP, and although between 2002 and 2006 this rate has fallen nearly 50%, caution is recommended in the analysis of this information since this pollutant is strongly influenced by meteorological parameters. [7]

On cities in the interior, networks monitoring air quality are rare. In the State of Sao Paulo, the CETESB maintains a network covering 12 cities outside the Metropolitan Area, but, in general, stations are limited in two or three pollutants. The State Foundation of Environmental Engineering of the State of Rio de Janeiro (FEEMA), also maintains monitoring stations within the state, but only in three cities, and generally monitors inhalable particles and/or ozone. [7,9]

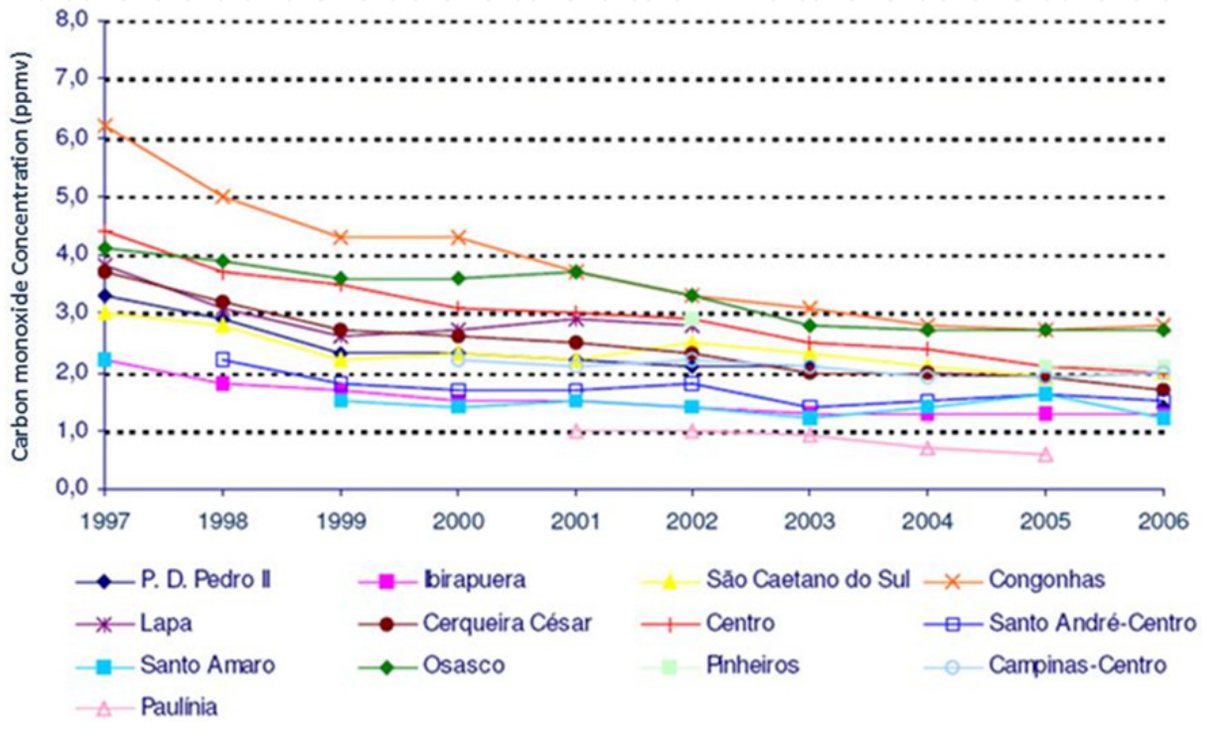

Figure 1. Annual Average Concentration of CO in the MRSP. [7]

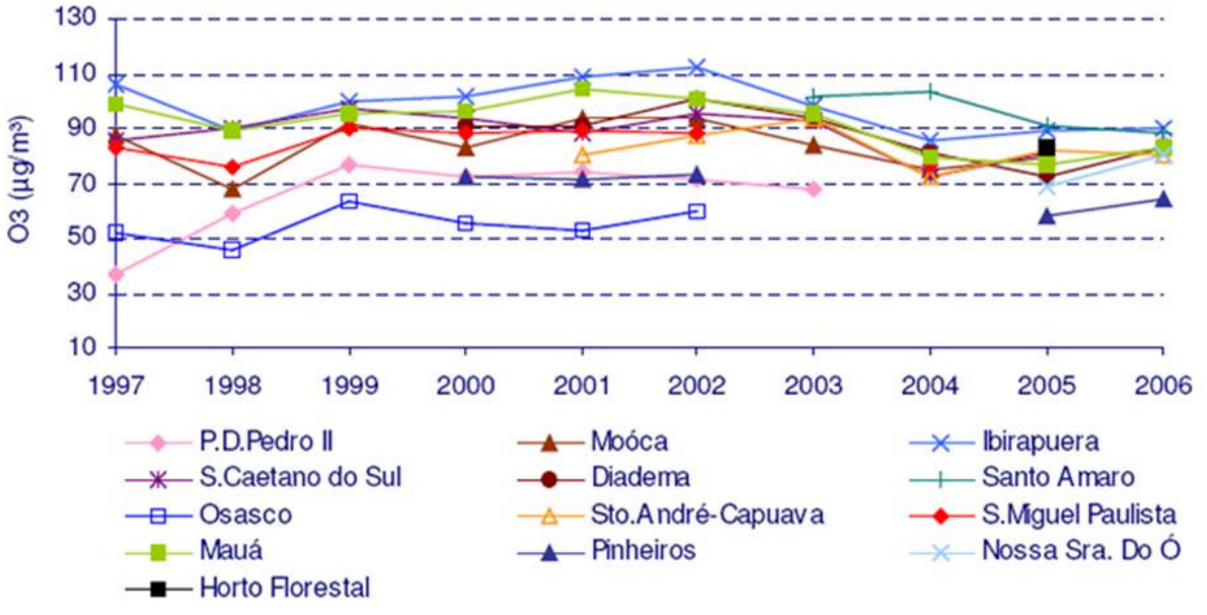

Figure 2. Annual Average Concentration Ozone in the RMSP.[7]

3. Midwest region: A case of Mato Grosso do Sul state

In Mato Grosso do Sul (MS), research in urban air quality is scarce. There is not continuous air quality monitoring stations on MS maintained by the Government. Some isolated initiatives take advantage of the existence of some databases of companies, which in accordance of their activities has monitoring stations in cities including Campo Grande and Tres Lagoas.

[10] developed inventory of pollutant emissions for the fleet of public transportation buses and minibuses in Campo Grande. Depending on the reference adopted for calculation, such as emissions of carbon monoxide are estimated at up to 46 tons/month, while hydrocarbons and nitrogen oxides, 12.7 and 80.6 tons/month, respectively.

[11] investigated the daily and seasonal variability of surface ozone in a region near the city of Campo Grande. The hourly variability in September 2005 indicates more intense concentration in the afternoons due to the action of sunlight, and lower at night. Concentrations were recorded, the minimum and maximum of 5.6 ppbv to 71.9 ppbv.

In the Midwest region of Brazil studies on emissions of air pollutants are sometimes related to seasonal fires in states as Amazonas (AM), Rondonia (RO), Acre (AC), Goias (GO), Mato Grosso (MT) and Mato Grosso do Sul (MS) very significant part of these fires reach a global scale . However, for the regional context, there is evidence that, particularly at the time of the dry season in the Midwest, the presence of ozone at low altitude may be related to the transport of biomass burning regions. [12]

[13,14] present studies on the high concentration of ozone in the dry regions, respectively, Goiania (GO) and Maringa (PR). In Goiania, balloons were launched to monitor weather conditions and the concentration of ozone. The average altitude of 2.0 km were recorded peaks of concentration of the gas up to 112 ppbv.

In Maringa, located in northern Parana, therefore, more distant regions where fires occur, surface ozone measurements seem to confirm the influence of long-range transport during the dry season. When confronted measures in January (rainy season) and August (dry season) during the afternoon, the variation can be greater than 80 ppbv between stations.

In this chapter we present some results of an extensive research done on one of the Brazilian regions,the Midwest region, which in the last ten years has increased its participation in the industrial economy. Tres Lagoas (20.75 S, 51.68 W) represents the largest urban area in the eastern state of Mato Grosso do Sul, the gateway to two major biomes the Cerrado and the Pantanal, that have rich biodiversity and plant and animal species found only in this part of the world. The acelerated economic growing of this region is due to installation of factories of various industries, especially pulp , thermoelectric power generation and steel mill.

Some regions of Brazil are passing by economic changes, which easily imply the production of various effluents as solids, liquids, or, as is the focus of this chapter, gas, and additionally, many of these regions outside the Rio-Sao Paulo, where studies in air pollution are not

consolidated, legislation and supervision are less intensive and restrictive and there is not relevant networks of air quality monitor.

As these are regions with no history of industrial impacts and that are at the beginning of its activity that the research results are intended as an instrument parameter for new scientific research in Brazil and elsewhere in the world. Figure 03 illustrates a clipping from the eastern to the urban area of Tres Lagoas featured, the Parana River and the areas of Sao Paulo State border, and with eucalyptus plantation for the pulp industry.

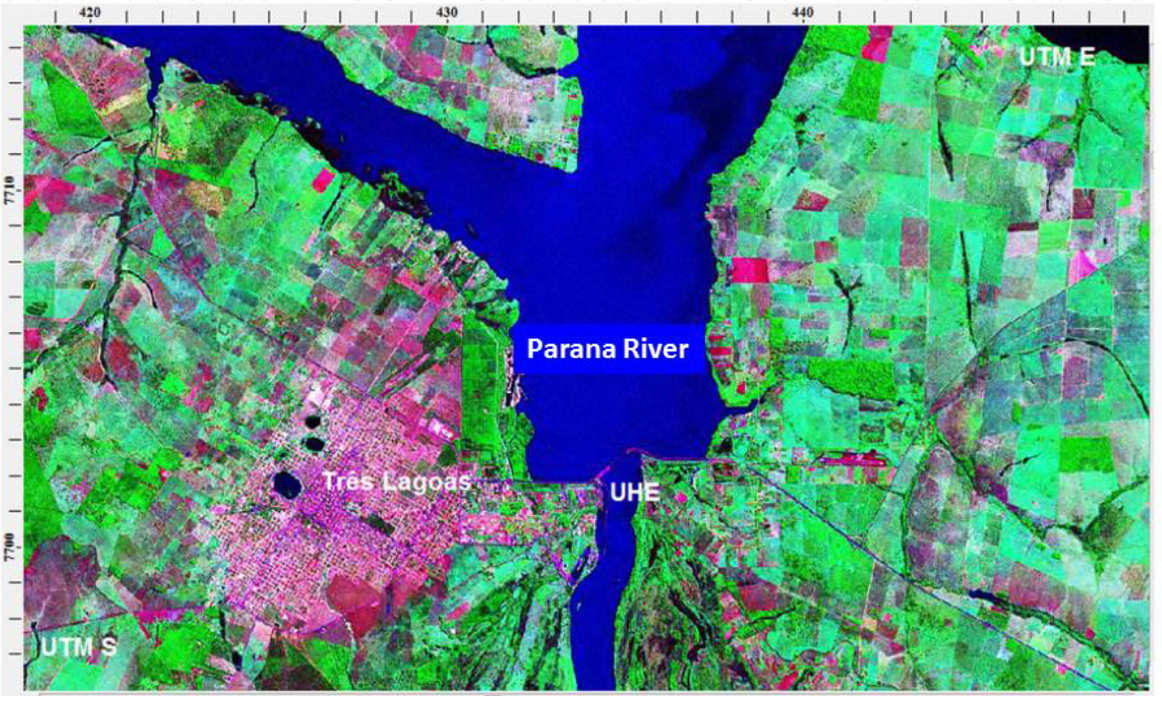

Figure 3. Image of Tres Lagoas City and Parana River.

4. Developing of the research

The sources of emissions of pollutants in the atmosphere, three groups were selected for investigation: Vehicular Sources, Biogenic Sources and Industrial Sources. The source vehicle through urban light fleet, is recognized as the greatest contribution in large urban centers to the outside world. Also, industrial sources, depending on the productive sector, effluent types and sizes, have a relevant role in the total emissions of a city. The biogenic sources in the present study are motivated primarily by its contribution to emissions of hydrocarbons, which, given their high reactivity, has a potential to contribute to the processes of formation and/or removal of secondary pollutants.

The research used different methodological resources to lead to results. In regions such as those examined did not have a monitoring network maintained by the public power, only stations, which by law, and due to the nature of the activity, have such monitoring stations in urban area of Tres Lagoas. Gas parameters monitored are carbon monoxide, nitrogen

monoxide, nitrogen dioxide and ozone, meteorological parameters are wind speed, wind direction, relative humidity, temperature, solar radiation and rainfall. In addition to monitoring were visited several companies and government agencies with the purpose of obtaining information to produce an inventory to assist in estimating emissions.

4.1. Inventory of gaseous emissions

In 1971, the U.S.Environmental Protection Agency (EPA) established the U.S. American National Emissions Data (NEDS), a kind of database on the sources of emissions. This measure directed the organization of an annual report, an inventory estimates of emissions from sources potentially polluting, helping directly subsequent measures to control air quality.

The Air Emissions Inventory comprises, strictly speaking, a list containing the information gathering that characterize the pollution potential of a geographic region or sector-specific human activity or natural.

Among the main information that derive from an inventory of emissions are the pollutants selected for evaluation, the emission sources that best represent the scenario being studied, the activity level of each emission source selected, the most appropriate emission factors for the productive sector or source in focus, the range of uncertainty associated with estimates of each source and, finally, estimates of emissions of each pollutant within their respective categories of sources. [15-18]

Some definitions of Atmospheric Emissions Inventory in the literature addressing its broader nature, this document is a response to the relationship between emissions and concentration of pollutants in a region. Among these definitions:

> "It is a compilation of pollutant emission estimates classified acoording to the different sources of emissions" [17]

> "Approach is based on an understanding of the quantitative relationship between atmospheric emissions and ambient air quality" [19]

Other definitions address the relationship of the information generated in the inventory with the need to manage air quality, control of emissions from sources, adequate supervision regulations. Two of these definitions are:

> "An air emissions inventory can range from a simple summary of estimated emissions compiled from previously-published emissions data to a comprehensive inventory of a facility using specific source test data that will be used to support compliance activities." [18]

> "An emissions inventory is the foundation for essentially all air quality management programs. Emissions inventories are used by air quality managers in assessments of the contributions of and interactions among air pollution sources in a region, as input data for air quality models, and in the development, implementation, and tracking of control strategies." [16]

The emissions inventory can be classified as to the procedures adopted for the preparation in two approaches: top-down and bottom-up. The top-down approach, more general, used as input data for calculating the total quantity of a given fuel consumption and associated with an emission factor that is representative of the type of fuel measured. This approach is useful in situations where information is scarce or not available, or the collection costs are high or the end use of the inventory does not justify the investment. In general, this approach examines the sources and areas, and in this case, the use of average emission factors and activity level obtained from national or regional reports reduce the accuracy of estimates. [20,21]

The bottom-up approach considers a large number of details of the source evaluated in the input data for calculation. Typically it is used for point sources. However it can be used for the source area when data are relative to the source in question by means of prior research. Requires more resources to collecting information for the specific location. In general, are more accurate than top-down approach, because it does not use global information reporting national and regional agencies, but information more directly related to the source evaluated. [20,21]

Different authors have prepared inventories of emissions of pollutants in urban areas such as Bogota, Buenos Aires, Mexico City, etc. and recommended the use of both approaches. The organization of information may involve the use of different tools to meet the approaches, such as using simulation programs, remote sensing images, emission factors from the literature, data from continuous monitoring of pollutants. [21-24].

The results of this research used both approaches to the emission inventories of vehicles, emissions from the power plant and gas phase biogenic hydrocarbons in the forest of eucalyptus and other plants. Details of the methodology can be found in documents of the Intergovernmental Panel on Climate Change (IPCC), and table of emission factors in AP42 U.S. Environmental Protection Agency.

4.2. Monitoring of ambient air - gaseous and meteorological parameters

Concentration measurements of gaseous pollutants were conducted on three different monitors of the mark Horiba, APOA models 360 (Ozone), APNA 360 (NOX) and APMA 360 (CO), installed in a Fixed Station Monitoring of Air Quality and Meteorological Parameters in the outskirts of the city, northeast to the central area, coordinated UTM: 427,944 mE, 7,702,272 mS, altitude 325 meters. These instruments are company-owned Petroleo Brasileiro S.A. and their data were kindly ceded, in its raw form, to the Engineering School of USP and Center for Environmental Research of UEMS for the realization of this work.

The data of air quality monitoring and meteorological were submitted to calculations using basic statistic and multivariate statistical analysis of principal components. The basic statistics was applied to all series of the parameters measured and accepted as validated for

the study, after coherence analyze. A multivariate analysis was applied to estimate the correlations between meteorological parameters and the average concentrations of ozone, carbon monoxide and nitrogen oxides.

5. Results and discussion

The results presented, in sequence, are part of investigation developed in eastern of MS, and it was gathered a group of information about the monitoring performed in primary pollutants for ozone formation and the meteorological behavior, and, also, the use a consolidated inventory of mobile and fixed sources.

Seasonal variations of NOx and CO for the daily cycle indicate similarities in the behavior of both pollutants. Their concentrations are higher at certain times of day (between 7 and 8 a.m. and 18 and 21 hours) in any month of the year, however, in the months between April and September peak periods are increased. Probably, the reduction of the average height of the mixed layer and/or temperature inversions of this period of months may explain, at least in part, increased concentration of CO and NOx. Figures 04 and 05 illustrate the seasonal behavior of NOx and CO for 2006 to 2005, years when there is less loss of data for both pollutants.

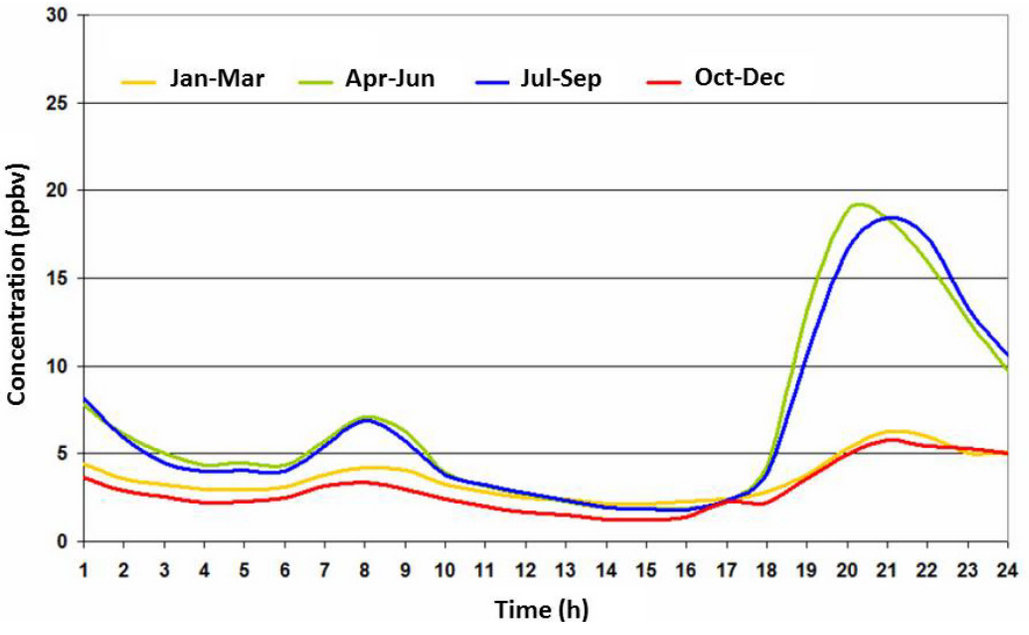

Figure 4. Seasonal behavior daily cycle of NOx at 2006.

The peak periods in both figures, are directly associated to the time of entry and exit of vehicular fleet of urban movement. This behavior indicates that the NOx and CO are available from the local atmosphere, probably mostly from vehicle emissions, given that other sources, such as ceramics and thermoelectric operate under almost continuous. The working of the ceramics kiln, on average during the firing process, 50 hours and, interchangeably, which ensures the discharge of pollutants in a nearly constant.

The Thermoelectric Unit of Tres Lagoas in a 24-hour cycle suffers almost no fluctuation in the levels of NOx that are emitted in their chimneys. On 11 October 2005, with ozone level recorded in 80 ppbv (threshold standard of air quality) to the average concentration of 16.9 ppmv NOx, the standard deviation did not exceed 3.6 ppmv.

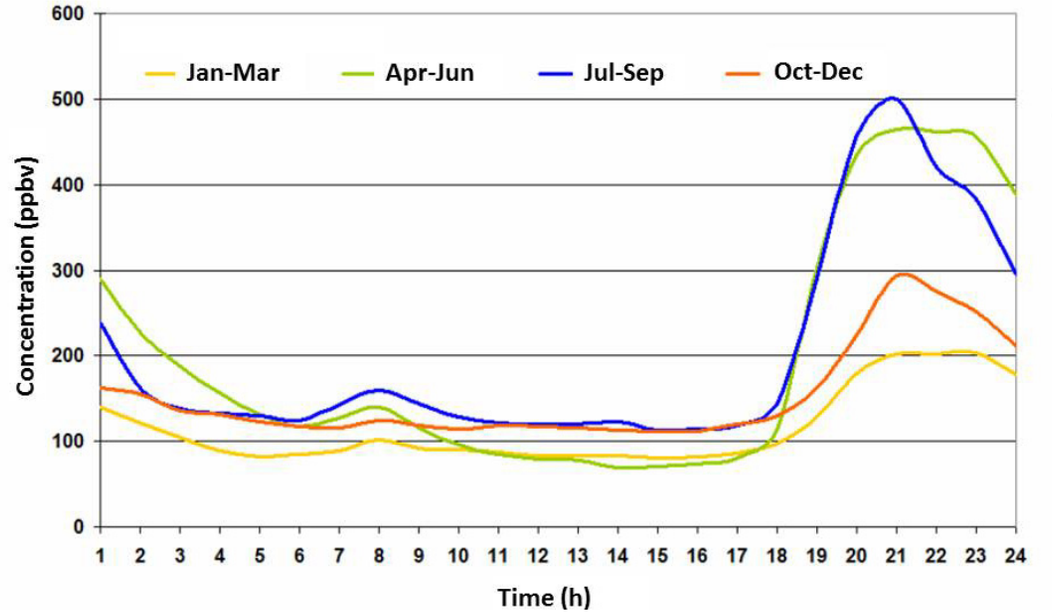

Figure 5. Seasonal behavior daily cycle of CO at 2005.

The behavior of NOx and CO, ozone precursors, are observed for some periods of the year for which data are available for both pollutants. The relationship kept between both NOx and CO, can be an indicator of a common source of emission. In 2006, the highest monthly average ozone occurred in September, and the week between 3 and 9 showed a strong linear relationship (R^2 = 0.85) between NOx and CO, Figure 06 illustrates this result.

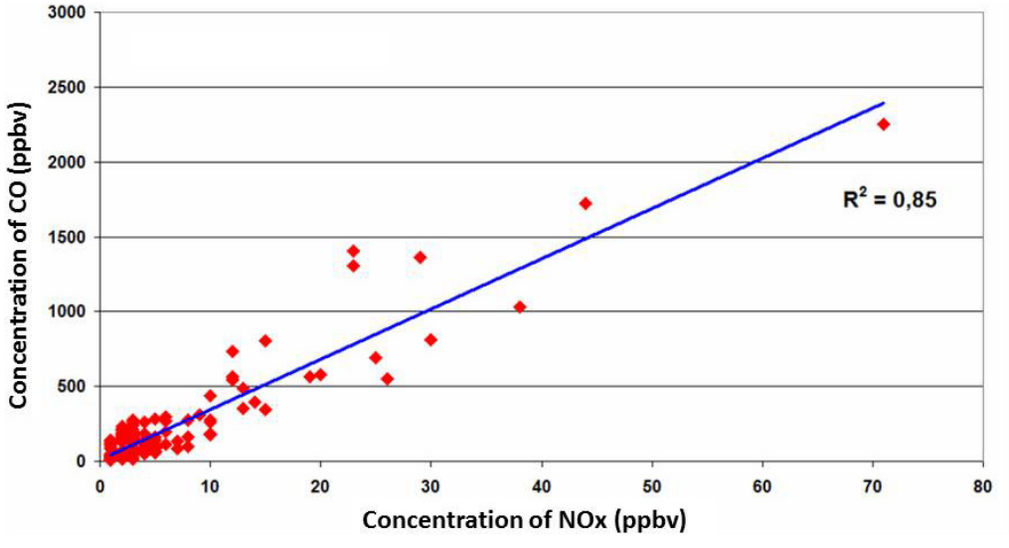

Figure 6. Relationship between NOx and CO for the period of 3 to 9 September 2006.

Moreover, in 2005, the month in which occurred the largest monthly average, in October, this behavior is not observed with the same intensity. The linear relationship between NOx and CO cannot be considered strong for the series of data from weeks 9-15 and 16-22 October 2005. In Figure 07 the ratio is more representative of a common source of both pollutants than in Figure 08, where R^2 = 0.12 shows weak linear relationship. In a test is disregarded one of the points of Figure 08, far away, with a concentration of NOx = 33 ppbv and CO =194 ppbv. This procedure resulted in an increase of R^2 (0.33) however did not alter the condition of weak linear relationship between NOx and CO for this period.

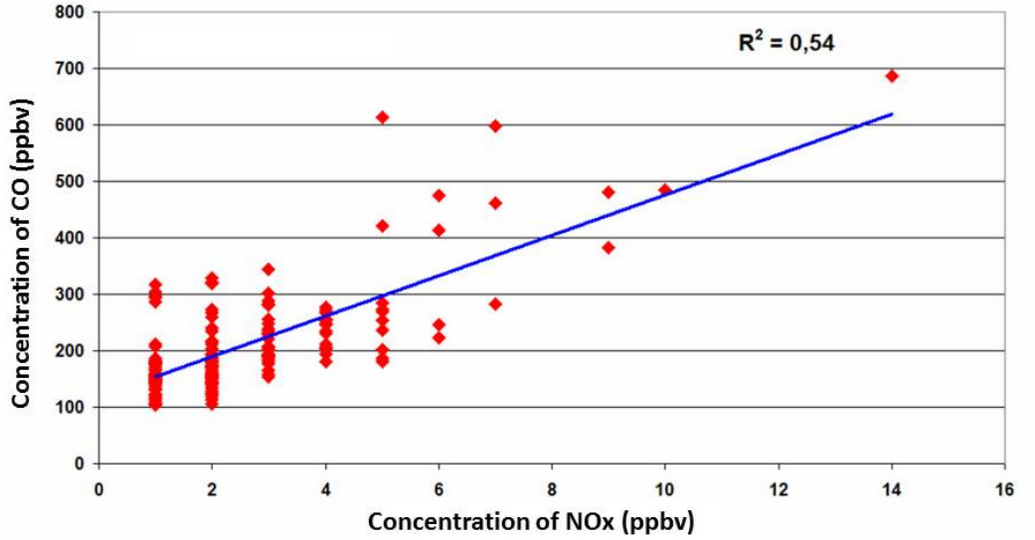

Figure 7. Relationship between NOx e CO for the period of 9 to 15 in October 2005.

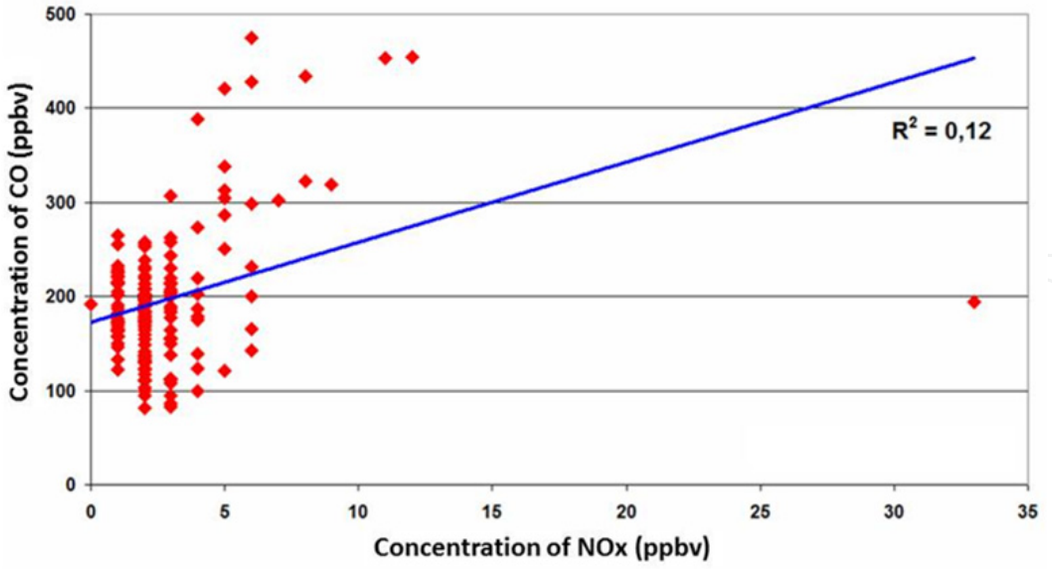

Figure 8. Relationship between NOx e CO for the period of 16 to 22 in October 2005.

Figure 09 illustrates the behavior of the average annual daily cycle of NOx and O3 for the year 2006, and Figure 10 for the series of CO and O3 in 2005. The choices of years in correspondence with the pollution are due to the larger number of valid data.

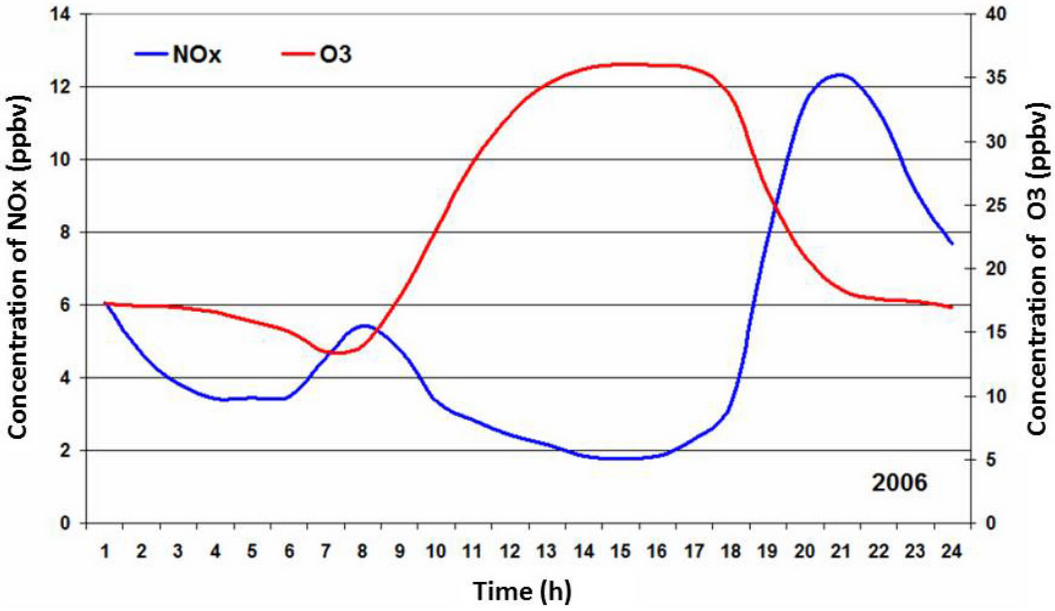

Figure 9. Daily Cycle of NOx and Ozone at 2006.

The NOx emitted initially in the form of NO from exhaust of the vehicle fleet later in the atmosphere, chemical reactions with peroxyl radical results in the formation of NO_2. As the intensity of solar radiation increases, photons with wavelengths below 420 nm break NO_2 molecules that allow, in the presence of oxygen (O_2) the formation of ozone.

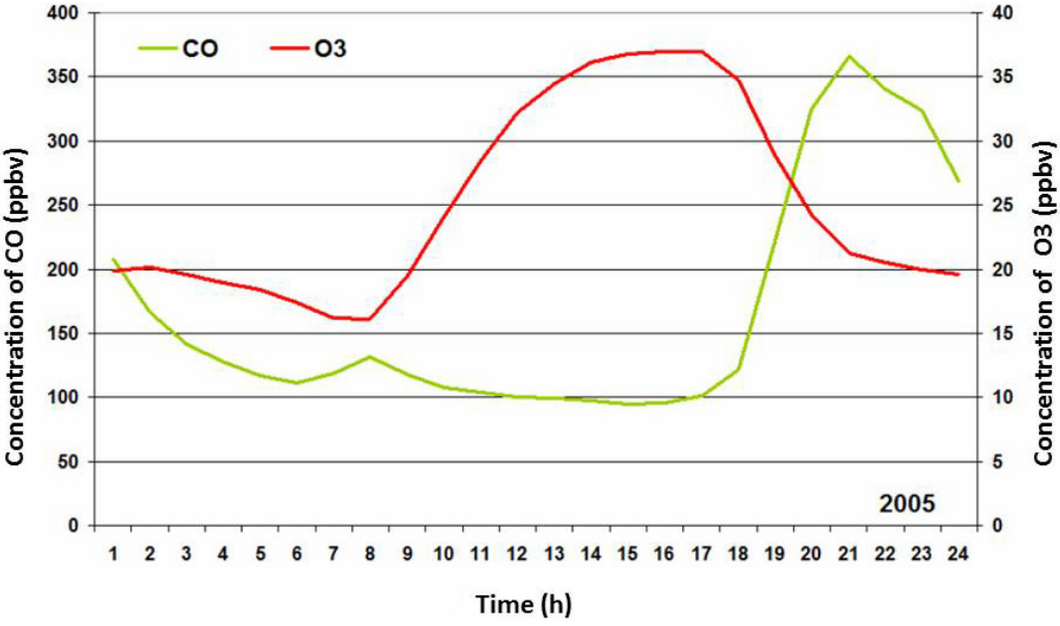

Figure 10. Daily Cycle of CO and Ozone at 2005.

NOx levels are directly related to the concentration of ozone, is to intensify the formation of O3 or even limit its formation. In the case of Tres Lagoas NOx levels are considered low, almost equivalent to concentrations found in rural areas, according to [2], which may partly explain the low ozone concentration.

According to [2] the concentration of carbon monoxide in the environment, for the Southern Hemisphere, should range between 60 and 200 ppbv. Mean levels of Tres Lagoas are close to this age, presenting, in a few months, comparable to peak concentrations of large cities such as Ribeirao Preto, in Sao Paulo State, which according [25] may have concentrations up to 3 ppmv.

Carbon monoxide while relatively stable (residence time 30 to 90 days) may react with the hydroxyl radical, which, in the presence of oxygen (O2), carbon dioxide and form hydroperoxide radical which therefore reacts with NO to NO2 in converting , triggering the process of formation of ozone molecules.

5.1. Relationship of the NOx, CO, ozone and wind conditions

Two periods were selected to analyze the relationships between pollutants, wind direction and speed, temperature and relative humidity. They are 6 to 9 January and 1 to September 4, 2005. Tables 01, 02, 03 and 04 illustrate results of the first period.

	Average Concentration of Pollutants (ppbv)			
Wind Direction	**%**	**CO**	**NOx**	**O_3**
≤ 90	60.4	108.6	0.4	16.6
90-180	10.4	207.8	2.4	12.6
180-270	7.3	264.3	4.0	7.3
> 270	21.9	143.7	0.9	16.8

Table 1. Pollutants Concentration and Wind Direction. (6-9 /January/2005).

The wind direction, predominant in the period 6-9 January, occurs toward Lake-town (NE-SW) by almost 70% of the time, being higher towards the city, 60.4%. In this direction the average concentrations of CO and NOx are lower and higher ozone when the wind blows from the lake to the city (Direction ≤ 90), and the process is reversed when the winds blow from the city to the lake, when the CO (264.3 ppbv) and NOx (4.0 ppbv) have their highest average concentrations and the minimum ozone (7.3 ppbv). The monitoring station is virtually between the lake and the city, thus the data suggest that higher concentrations are caused by sources, whether mobile or fixed, present in the city.

	Average Concentration of Pollutants (ppbv)			
Wind Speed	**%**	**CO**	**NOx**	**O_3**
≤ 1,0	31.3	206.1	2.4	10.9
1,1-2,0	55.2	108.1	0.3	17.4
2,1-4,0	13.5	102.2	0.2	18.8
> 4,0	-	-	-	-

Table 2. Pollutants Concentration and Wind Speed. (6-9/January/2005).

The occurrences of wind speeds below 2.0 m/s represent 86.5% of cases, 55.2% between 1.1 and 2.0 m/s that are typical of the daytime period. For this last category of wind

speed average concentrations of CO, NOx and O3 are similar to those for the wind that blows from the lake to the city. The reduction of the concentrations of CO and NOx as the wind speed increases indicate better dispersion of pollutants, so conversely, lower speeds, require greater stability of the atmosphere, the smaller the dispersion. Speeds below 1.0 m/s occur, mostly at night. At this speed category the average concentrations of NOx and CO reach the highest values, respectively, 2.4 and 206.1 ppbv, while ozone is reduced to the lowest level, of course, in case night due to the absence of the photochemical process.

5.2. Relationship between NOx, CO, ozone and relative humidity

The relative humidity can influence the flow and hence the actin photochemical processes. The average concentration of ozone decreases with increasing relative humidity, however for percentage of moisture above 80%, ozone, and also other pollutants may suffer reductions due to removal by rainfall.

The Table 03 illustrates that, indeed, the ozone is reduced due increasing the percentage of moisture, but should not be, in every day, directly because the action of precipitation, even as the measures rainfall occurrences indicate only the days 7,8,9, or before 8 am or after 19 hours. In six days the precipitation occurred in the period (afternoon), resulting in lower values of O3, CO and NOx. Table 04 illustrates pollutants for days 6-9 January.

	Average Concentration of Pollutants (ppbv)			
% Relative humidity	**%**	**CO**	**NOx**	**O_3**
≤ 40	0	-	-	-
40-60	14.6	93.6	-	21.1
60-80	32.3	127.4	0.5	18.1
> 80	53.1	156.5	1.4	12.4

Table 3. Pollutants Concentration and Relative Humidity(6-9/January/ 2005).

	Daily Average Concentration of Pollutants		
Days	**CO**	**NOx**	**O_3[1]**
6	114.7	0.6	17.0
7	148.7	1.1	19.1
8	180.3	2.0	20.4
9	108.0	0.1	21.4

Table 4. Average Concentration of Pollutants relating to day 6 to 9 January 2005.
[1] Mean values for the period between 11 and 17 hours.

It is possible verify that the mean values of CO and NOx are smaller, also on day 9 in which no precipitation occurred during the day. However, between 20 hours (day 8) and 8 o'clock in the next morning, the 9th, it rained almost 11.2 mm, assisting in the removal of Local air pollutants

5.3. Relationship between NOx, CO, ozone - conditions of temperature

Although the temperatures for the period in focus, are all greater than 20 ºC, it is possible to note differences between the average concentration of pollutants in the range of 20-30 ºC and above 30 °C. The ozone precursors undergo a reduction in its concentration with increasing temperature, while the level of ozone rises. There are several parameters which influence the concentration of pollutants, but the higher temperature can also assist the formation of ozone, and therefore the consumption of CO and NOx due to the role of the temperature in photochemical processes. Table 05 illustrates the influence of temperature on the concentration of pollutants.

	Average Concentration of Pollutants (ppbv)			
Temperature	**%**	**CO**	**NOx**	**O_3**
≤ 10		-	-	-
10-20		-	-	-
20-30	76.0	151.3	1.2	13.9
> 30	24.0	95.4	0.04	20.8

Table 5. Pollutant Concentration and Temperature. (6 9/January/2005).

5.4. Relationship between NOx, CO, ozone - conditions of the wind

The results of the wind for the period September, Table 06, indicate again the predominant direction of Lake-town, about 80.2% of the time analyzed. However, the direction of the wind flow was reversed to Town-lake, 53.1% of the time. The highest average concentrations of ozone, 40.5 and 32.9 ppbv, still, respectively, occur in directions ≤ 90 and> 270, as from January. By comparison, in January the values of the average concentrations of ozone in these directions were similar, but in September the average concentrations of ozone, winds coming from the lake were higher, with differences of up to 23%.[26]

Carbon monoxide has higher average concentrations for January for directions> 270° (417.0 ppbv) and between 90° and 180° (666.8 ppbv). However, these points wind directions in 1/5 of the evaluation period, as represented in January 1/3. The NOx exhibits the same behavior pattern in January, but with higher average concentrations up to 14 times.

Winds off the lake from the city to carry higher concentrations of NOx (55.6 ppbv), while in the opposite direction, the average is not more than 8.0 ppbv. The ratio of inversion between O3 and NOX, regardless of direction, seems to remain, while carbon monoxide undergoes variations between the direction > 270 and 180-270 °.

The directions in which the CO has the highest concentrations occur at night, in which, according to Figure 05, even for seasonal variations in the period of early evening CO concentrations rise, and especially in the month on September they reach levels above 500 ppbv. The reduction of the mixed layer in the evening may result in the transport of pollutants from higher regions to the surface. And in the second half, in Brazil, there are high numbers of fires in the Amazon and the Midwest regions that can affect distant areas,

as indicated by [15]. Table 06 illustrates the information talked about above the average concentration of pollutants as a function of wind direction.

	Average Concentration of Pollutants (ppbv)			
Wind Direction	**%**	**CO**	**NOx**	**O_3**
≤ 90	27.1	235.7	8.0	40.5
90-180	10.4	666.8	28.5	14.2
180-270	53.1	147.4	55.6	16.6
> 270	9.4	417.0	16.8	32.9

Table 6. Pollutant Concentration and Wind Direction.(1-4/September/2005).

Table 07 illustrates the average concentrations of pollutants and the average speed of the winds. Carbon monoxide and nitrogen oxide reducing their concentrations with increasing wind speed; this is due to better dispersion of pollutants. However, the same does not occur with ozone, which for speeds greater than 4.0 m/s concentration rises to 30.7 ppbv. According [26] at high speeds can reduce the stability of the mixed layer allowing the entry of additional upper ozone layer, however higher speeds should alleviate this scenario.

High concentrations of CO and NOx emissions associated with velocities below 1.0 m/s must occur, in most cases, during the night, in view of low media concentrations of ozone, 8.8 ppbv.

	Average Concentration of Pollutants (ppbv)			
Wind Speed	**%**	**CO**	**NOx**	**O_3**
≤ 1,0	20.8	639.2	31.5	8.8
1,1-2,0	24.0	232.5	4.7	33.4
2,1-4,0	36.5	114.9	7.4	24.0
> 4,0	18.7	106.2	3.1	30.7

Table 7. Pollutant Concentration and Wind Speed.(1-4/September/2005).

5.5. Relationship NOx, CO and ozone - relative humidity

Table 08 concerns the relationship of pollutants to the air humidity reflects similar behavior to that found for the period 6-9 January. The increase in humidity implies the reduction of ozone and NOx and CO increased. As mentioned earlier, the presence of water in the air flow affects the actin and thus the photochemical processes and the formation of ozone.

	Average Concentration of Pollutants (ppbv)			
% Umidade	**%**	**CO**	**NOx**	**O_3**
≤ 40	10.4	90.3	2.3	51.4
40-60	29.2	341.7	15.2	29.4
60-80	46.9	282.2	12.3	18.2
> 80	13.5	69.0	2.2	13.9

Table 8. Pollutant Concentration and Relative Humidity.(1-4/September/2005).

The intensity of solar radiation for the two periods is similar, with January showing slightly higher values. In percentages above 80%, the rapid reduction of NOx and CO, and O3 less intense, are related, with higher chances of occurrence of rainfall. But, during the evaluation period precipitation occurred within 20 hours of the day 1 and 14 hours of the day 2, it represents about 6% of the period. This situation favors the removal of pollutants from the atmosphere, thereby reducing its concentration.

5.6. Correlation between a group of pollutants and meteorological parameters

Another statistical analysis was the principal component analysis, considering the time series of meteorological parameters of wind direction and speed, temperature, relative humidity and radiation pollutants CO, NOx and O3.[26] The periods, above, 6-9 January and 1-4 September in 2005 were used to compose the correlation matrices. Tables 09 and 10 illustrate the matrices.

	CO	NOx	O_3	D	V	T	U	R
CO	1							
NOx	0.90	1						
O_3	-0.65	-0.70	1					
D	0.26	0.26	-0.06	1				
V	-0.49	-0.54	0.59	-0.15	1			
T	-0.08	-0.11	0.50	0.19	0.32	1		
U	0.25	0.28	-0.65	-0.15	-0.43	-0.96	1	
R	-0.26	-0.16	0.39	0.17	0.28	0.54	-0.55	1

Table 9. Principal Component Analysis for the period from 6 to 9 January 2005

In both tables, 09 and 10, the strongest correlations between pollutants, occur with CO and NOx.Correlations with values of 0.89 and 0.90, as occurred with CO and NOx, indicate, in fact, compared strong linear between the two pollutants, and that possibly arise from the same source.

	CO	NOx	O_3	D	V	T	U	R
CO	1							
NOx	0.89	1						
O_3	-0.38	-0.54	1					
D	-0.07	0.02	-0.40	1				
V	-0.50	-0.66	0.28	-0.11	1			
T	0.19	-0.03	0.76	-0.35	0.02	1		
U	-0.09	-0.05	-0.67	0.28	0.31	-0.77	1	
R	-0.31	-0.38	0.58	-0.38	0.14	0.43	-0.56	1

Table 10. Principal Component Analysis for the period 1 to 4,September, 2005.

Both the CO and NOx average correlation remains strong with two other parameters in both periods, the ozone concentration and wind speed, and inverse correlations were negative. This fact, combined with the strong linearity for each other (CO and NOx) and ozone concentrations remain at average levels up to 3 times lower than the established by legislation (close to levels from rural areas) seem to confirm the greater weight of the dynamics of pollutants are related to sources and local meteorological conditions.

Ozone-average correlation remains strong in both periods, with the temperature, relative humidity and solar radiation, which were expected. However, regarding the direction and wind speed suffers considerable variations. In January, the correlation of ozone with the wind, virtually nonexistent points was the statistic (-0.06), while for the period September to correlate with the wind direction is close to the average (-0.40). Table 06 showed that the highest average concentration of ozone for the period 1 to September 4 were from the region of Jupia Lake (between 0º and 90º and 270º and 360º), no such sources directions.

5.7. Analysis of the results of simulation training ozone

Additionally, a computer program, for simulation, provided by EPA was able to estimate the concentrations of ozone in urban areas. The input data for simulation were taken from the Atmospheric Emission Inventory produced on this investigation and the database of monitoring the local atmospheric concentration of CO and NOx. As no data are available concentration of volatile hydrocarbons were adopted in Tres Lagoas three different concentration levels: 800 ppbC (polluted urban region), 150 ppbC (typical urban region), 50 ppbC (rural), for the performed simulation.

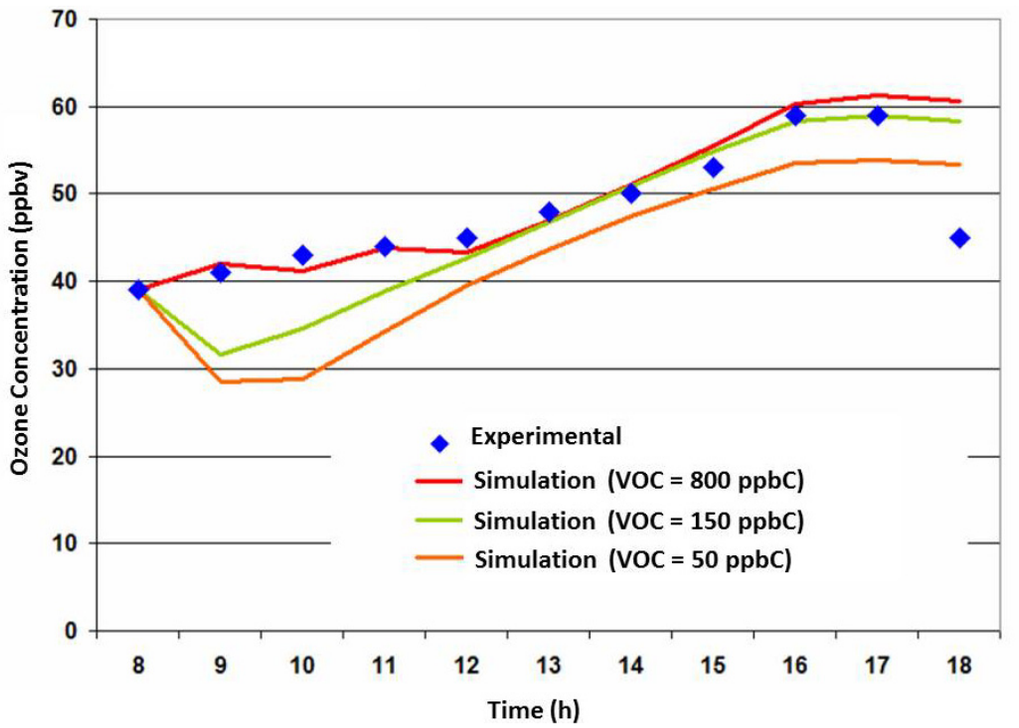

Figure 11. Simulation of the formation of ozone at different concentrations of Volatile Organic Compounds.

The results obtained, and illustrated in Figure 11, indicate that variations of ozone with the different levels of hydrocarbons do not undergo significant changes, indicating a possible limitation of the formation of ozone due to the NOx. The concentration curve that best fits the experimental data was 800 ppbC, which it can be consider high value, and maybe no real, additional investigations about hydrocarbon gas, with monitor devices must be performed to elucidate this question.

In considering much lower concentrations, as 50 ppbC, the difference, near the midday, in which solar radiation is more intense, is not significant. But for the initial hours of the day the difference increases. In the morning, in general, the mixing height layer is at its lower levels and may cause the entry of the ozone layer to the upper surface.

6. Conclusion

The highest emissions were carbon monoxide, with the majority coming from the vehicle fleet. Estimates indicate that in 2005 and 2006 emissions of the vehicle fleet accounted for 97% of emissions of carbon monoxide, and about 53% of nitrogen monoxide from the sources analyzed, which generally agrees with results other urban areas where emissions from the fleet are dominant. The total emissions of both pollutants CO and NOx emissions in 2006 were, respectively, 290.00 and 2,614.40 tons, whose magnitude is low, of course, compared to other cities that have air emissions inventory, which in general are of size greater the Tres Lagoas, or are attached to larger ones.

The statistical results show that the concentrations of pollutants, CO and NOx are well correlated with meteorological parameters, demonstrated that their sources must be local. The statistical correlation between CO and NOx reaches 0.90, confirming the linear dependence between them.

The computer simulation in order to evaluate the role of hydrocarbons showed that the local atmosphere, although with potential sources of NOx, this source is an agent for limiting the formation of local ozone. Compared with simple equations under steady state, it shows similar results, with a slight discrepancy in the morning. The biggest difference for the model that uses the steady state condition is in September, dry season. In January, the correlation between the curves suggests low concentrations of hydrocarbons in the atmosphere, but also, the rainfall can cause wet deposition, or the reduction of the action of actin flow. This issue must be better investigated.

The assessment of emissions and behavior of the concentration of primary and secondary pollutants arising out of or caused by existing sources so far are not sufficient to cause degradation scenarios of air quality. However weather conditions may lead to intensification of the action of pollutants in urban areas. The information available to indicate that the air quality in Tres Lagoas, the scope for analysis, is within the standards acceptable by current brazilian law, and some pollutants at concentrations equivalent to the average levels in rural areas indicated in the literature.

The original contribution of this work is to be a reference for future assessments of air quality in this region, where industrial growth is accelerated and the government has not yet manifested in monitoring policies and actions for monitoring the impacts on local and regional atmosphere, or its possible consequences for the environment.

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Acknowledgement

Our sincere gratefully to FUNDECT for funding and supporting research and PETROBRAS S.A. for their collaboration.

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