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# Diagnosis of the air quality in a zone affected by combustion gases sources

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In this paper a diagnosis of the air quality was made in the south-east zone of Santa Clara city, Cuba. For it is developed a methodology that includes: inventory of all the combustion fixed sources of this area, experimental evaluation of emission with the Emissions Analyzer System ECOM-SG$^{plus}$, modelling of the dispersion gases concentration by the methodology of the NC 39:1999, immissions measurement and evaluation of the environmental impacts of the sources emissions by applying the life cycle assessment. The method allows to evaluate the air quality in the zone which is acceptable with higher incidence is the $SO_2$ pollutant in the area around the new hospital. Finally the life cycle analysis shows a low influence on the environmental performance of the sources for the generation of steam compared with generation of electricity source and a higher impact category is breathing for inorganic compounds.

## 1. Introduction

The deterioration of the quality of the air is one of the main environmental problems of the cities of the world and not developed countries, as Cuba, is related to the use of obsolete technologies in the production and the services, the use of fuel of bad quality and vehicular transport with a bad technical state. For that reason the monitoring of the quality of the air is directed to the systematic evaluation of the tendencies in the quality levels of the air to protect the health of the population and to diminish the emissions of greenhouse effect. In several countries, there are for each pollutant guides and norms that establish the permissible maximum concentrations of the atmospheric pollutants during a defined period and air dispersion models are used that calculate the pollutant concentration downwind of a source using information on the contaminant emission rates, characteristics of the emission source, local topography and meteorology of the area . (Bluett, et al., 2004). Also the countries have networks of monitoring of the air quality, but it is not easy in some cities to select monitoring stations that give a representation of the quality of the air and cities exist that do not have these stations (Jeves, 2007). This paper will use a novel procedure to do the diagnosis of the air quality in one urban zone of the Santa Clara city which do not have monitoring stations.

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## 2. Climatic Characterization

Santa Clara city is located in the center of Cuba in Villa Clara province, as Cuba, this has a tropical climate, seasonally humid with maritime influence. There are two periods in the climate the wet period from May to October and dry period since November to April. In this city, the annual average temperature is the 24 $^{o}$C and values maximums average in the wet period in July of 26.4°C and values minimal average of 20.7 °C in January. The relative humidity is high, the values annual average of relative humidity has the variability of 15.1 % in one range between 93 % - 55 % and the historical average relative humidity is 79 %. The wind of the East region and wind speed is around to 5.2 Km/h in wet period and 7.49 Km/h in dry period.

## 3. Characterization of diagnosis area

The diagnosis of the air quality was carried out in south-east zone that is showed in figure 1.This zone is characterized to be flat, with buildings of half height, open spaces between these and wide streets (Barceló. ,1986). There are some hospitals and a great daily concurrence of people in this area. The typical climatic conditions are the same that were mentioned before, according to the climate of Santa Clara city. The points indicated in figure 1 are representative points in the main streets of the zone and near the sources that will be studied their emissions.
In this, there are diverse sources which harmfully cause the pollution, due to the need to use the fossil fuel combustion for the generation of steam and electricity. In the area, there are eighteen point sources and vehicular transport.

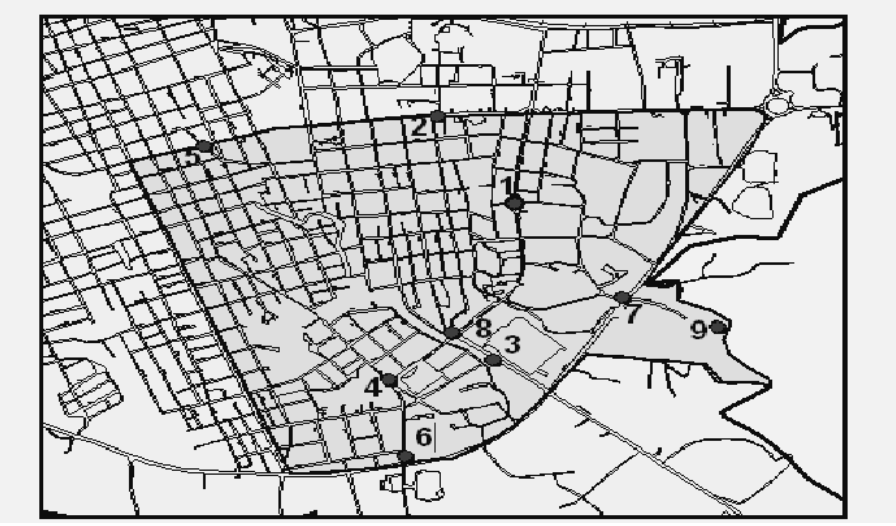


*Figure 1: Map of study Area*

In order to do the diagnosis of the air quality in a zone is developed a methodology that includes: Inventory of main point sources and experimental emissions evaluation, experimental immissions evaluation in open spaces and main streets of this area, the

modeling of the combustion gases dispersion and evaluation of the categories impact of the emissions by applying the methodology of life cycle assessment analysis.

## 4. Results and analysis of research methodology.

Of the inventory of point sources located in this area, the main considered in this diagnosis were five point sources that use small boilers for the steam generation. There are: two hospitals, Soft Drink Factory, Coffee Toaster, and Medicine University. Also, it was considered an electrical plant with sixteen internal combustion engines. These sources are near of points 3, 8,4,2,6 and 9 in Figure1.
The experimental emissions evaluation were measured with ECOM- SGPLUS or Testo 300 XL-1. Emissions Analyzing Systems (ECOM–SGPLUS, 2000). The averages values measured to 75% of the load capacity in one engine of the electric plant and other measured made up in the boiler steam are in table 1.

*Table 1 Emission of substances in the point sources*

| Sources | C(CO) (g/s) | C(SO2) (g/s ) | C(NOx) (g/s) |
|---|---|---|---|
| New Hospital | 0.066 | 3.700 | 0.710 |
| Infantile Hospital | 0.007 | 0.170 | 0.061 |
| Soft Drink Factory | 0.024 | 0.320 | 0.099 |
| Coffee Toaster | 0.4465 | 0.0043 | 0.00578 |
| Medicine University | 0.130 | 0.370 | 0.380 |
| Electric Plant . | 0.1595 | 0.1275 | 0.022 |

The experimental immissions evaluation were realized in seven points that appear in the Figure 1. The automatic equipment was used, Multiwarn II, with three electrochemical sensors for the concentrations of $SO_2$ NOx and $H_2S$. Also it has one infrared sensor for hydrocarbon concentrations. (Dräger Sicherheitstechnik, 2000). The results are showed in the Table 3.

*Table 2 Immission values of pollutants*

| | | mg/m$^3$(20 min) | | | ppm |
|---|---|---|---|---|---|
| Points | Description | $H_2S$ | $SO_2$ | NOx | Hc |
| 1 | Double Via Round | 0.502 | 0.255 | 0.008 | 396 |
| 2 | Coffee toaster | 0.154 | 0 | 0.081 | 321 |
| 3 | Ave New Hospital | 0.013 | 0 | 0.019 | 284 |
| 4 | Soft Drink Factory Corner | 0 | 0.013 | 0.007 | 576 |
| 5 | Central street | 0 | 0.265 | 0.001 | 386 |
| 6 | Medicine University | 0 | 0.360 | 0.088 | 447 |
| 7 | Oxygenate Plant | 0 | 0.005 | 0.081 | 206 |
| Standard Value NC 39:1999 (mg/m$^3$, 20 min) | | 0.008 | 0.500 | 0. 085 | ----- |

The results of Table 2 showed an acceptable air quality in this zone according to NC 39:1999 for three pollutants, however, the values to $H_2S$ concentrations is major than

the Standard Value according to the NC 39:1999.in Double Via Round, Coffee toaster and Ave. New Hospital.

The modeling of the combustion gases dispersion was carried out according the model dispersion in the Cuban norm, Berlyand, 1975 proposed a non Gaussian model which can apply in zones as the study area (flat, with buildings of half height) . To model, data of emission source, weather data and map of the studied region are used.

The results by NMDC (Cuban Norm Dispersion model) appear in the Figures 2,3 and 4. There are following:

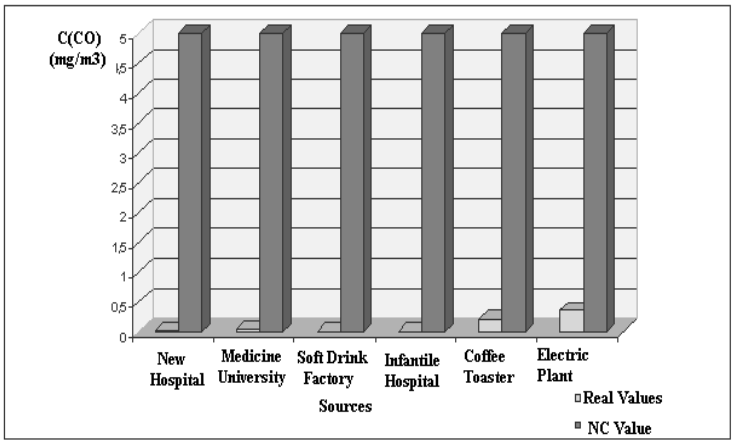


*Figure 2: Maximum Concentrations for Carbon Oxide in 20 minutes*

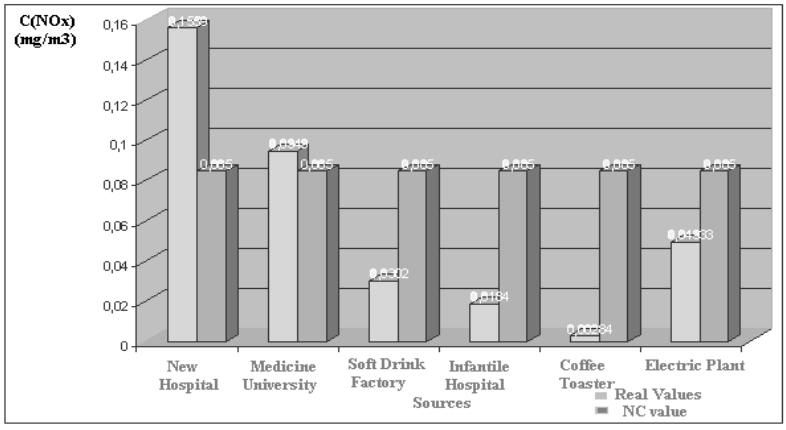


*Figure 3: Maximum Concentrations for Sulphur Dioxide in 20minutes*

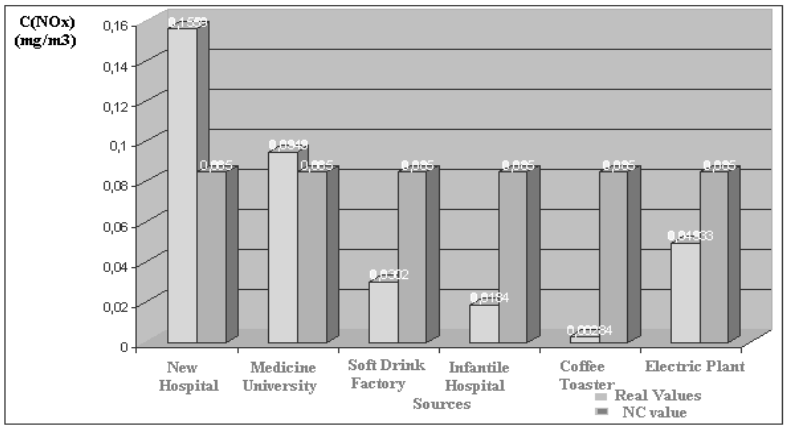


*Figure 4: Maximum Concentrations for Nitrogen Dioxide in 20minutes*

In the figures are observed the calculated Permissible Maximum Concentrations for Nitrogen Dioxide (NO2) in New Hospital and Medicine University are major than the Standard Value according to the NC 39:1999. Also, is the same result for the Sulphur dioxide ($SO_2$) concentration in New Hospital. Therefore, It is evidence by dispersion model that the area of greater polluting agent concentration is the New Hospital. (Macdonald 2003).

Finally in the evaluation of the impact categories by means of the eco-indicator 99 used in the software SIMAPRO the results demonstrated affectation in the categories of impact of climatic change, acidification and eutrophication and breathing of inorganic compounds. The most important impact was produced by this category and the source with more incidence in this category was the electric plant electric because in this plant, ten engines were working with emission rates similar to reported in Table 1. The results appear in Figure5.

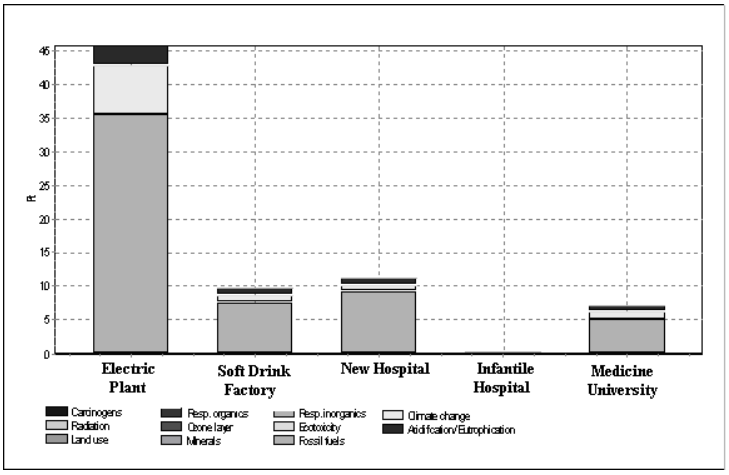


*Figure 5: Contribution of the sources to categories of impact.*

## 5. Conclusions

The procedure carried out is valid in order to integrate some considerations in this methodology of the diagnosis of air quality. The methodology applied allow to verify that the quality of the air in this zone is acceptable however the experimental values of the emissions and the dispersion model show that the polluting agent of greater incidence is the $SO_2$ and that the area of greater affectation is the New Hospital. Also the experimental values of the levels of immission in the zone show affectation by the $H_2S$ concentration. The categories of impact affected were climatic change, acidification and eutrophication and breathing of inorganic compounds and the most important impact was produced by electric plant electric.

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