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ASSESSMENT OF DAILY AND ANNUAL CONCENTRATIONS OF PM_{10} IN THE CITY OF FLORIANÓPOLIS

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Abstract: To investigate the air quality in the city of Florianópolis (state of Santa Catarina, Brazil), sampling for PM_{10} was performed using a high-volume sampler. The monitoring was conducted between November 8, 2011 to June 6, 2016 with a total of 225 samples. The annual and daily concentrations were compared to Brazilian (CONAMA 003/1990, State of São Paulo) and international (WHO, U.S. EPA and EU) air quality standards. The highest daily concentration of PM_{10} was 87 µg m^{-3} observed in 2011. This result is lower than the current limit of 150 µg m^{-3} set for Brazil and the U.S. EPA; however, it is higher than that recommended by the WHO, the final target of the São Paulo state and the EU standard (i.e., 50 µg m^{-3}). In contrast, EU standard allows 35 exceedances each year for 24-h concentrations of PM_{10}. The historical average of PM_{10} concentration was 24 µg m^{-3} (annual range from 20-32 µg m^{-3}). Therefore, annual means violate in all years the WHO guidelines and the target value of the state of São Paulo of 20 µg m^{-3}. The maximum annual average established by CONAMA 003/1990 of 50 µg m^{-3} was exceeded, as the EU standard of 40 µg m^{-3}. Furthermore, the temporal profile of the PM_{10} concentrations was investigated. According to up-to-date air quality standards in Brazil, the air quality in Florianópolis complies with the permissible limits for PM_{10}.

***Keywords*:** air pollution, inhalable particulate matter (PM_{10}), monitoring, air quality standards.

INTRODUCTION

The air pollution particularly due to particulate matter with aerodynamic diameter less than 10 µm (PM_{10}) is a global issue that can directly affect the human health and the environment. Airborne particulate matter (PM) is a pollutant composed of solid and liquid droplets (dust, soot, oil, metal and pollen) that can remain in suspension for long periods in the atmosphere due to its diminutive size, usually less than 100 µm. PM originates in several human activities, with emphasis on industrial and vehicular emissions (COSTA et al, 2009). Additionally, PM can also be emitted by natural sources, such as volcanic eruptions and resuspension of soil material because of wind action (COLLS; TIWARY, 2010).

Extensive studies have established linkage between the size of the particles and the type and intensity of adverse effect caused in humans. Fine particles ($PM_{2.5}$) have been more strongly associated with mortality and morbidity, whereas coarse particles ($PM_{2.5-10}$) have been related to respiratory hospital admissions (MINGUILLÓN et al, 2008). The adverse characteristics associated with PM_{10} involves both the shape and mean aerodynamic diameter particle, as the chemical composition. Besides, it is clearly understood that the air quality of a certain site depends not only on emission sources, but also more decisively on meteorological elements with multifaceted characteristics present at several spatial and temporal scales (JUNENG et al, 2011).

Undoubtedly, monitoring is a fundamental pragmatic tool for the management of air pollution. Many monitoring activities are performed for compliance purposes. In this regard, current Brazilian federal legislation on air quality is established by Resolution CONAMA N° 003/1990 (CONAMA, 1990), which includes ambient air limits for PM_{10}. Moreover, in Brazil, the Decree N° 59.113 of the State of São Paulo (São Paulo, 2013) stands out, because had its limits updated based on World Health Organization guidelines (WHO, 2006) and European Union *EU* regulatory framework (European Commission, 2008).

This work reports a comparison of both short-term (daily) and long-term (annual average) concentrations of PM_{10} monitored between 2011 and 2016 in the city Florianópolis with air quality standards. Moreover, we explored the temporal variability of the PM_{10} concentrations over the months of monitoring.

METHODS

The study occurred at the Federal University of Santa Catarina, located in Florianópolis (Santa Catarina, Brazil, 27°36'02.2"S, 48°31'05.7"W). PM_{10} samples were collected using a high-volume sampler (Energética Qualidade do Ar, Brazil) equipped with PM_{10} cutting head to collect the target pollutant on a glass fiber filter (GE Healthcare/Whatman, 0.6 µm pore size; 20.3 cm x 25.4 cm). The sampling procedures followed the guidelines of the Brazilian standard ABNT NBR 13412/1995 (ABNT, 1995). The net mass gain of the pollutant was obtained using an electronic micro balance (AY220; Shimadzu, Japan) with 10^{-4} accuracy. Consequently, PM_{10} concentrations were determined by gravimetric analysis due to the ratio of the mass retained on the filters and the air volume drawn by the equipment during sampling. Results were corrected to the standard condition (298 K and 1013 mbar).

Meteorological data (i.e., temperature and atmospheric pressure) was obtained from the LEPTEN weather station (www.lepten.ufsc.br), which is located ≈ 300 m from the study area. A total of 225 samples were collected between October 2011 and June 2016.

The criteria used for comparison purposes were Resolution CONAMA N° 003/1990; final goal set in Decree N°. 59,113 for the state of São Paulo; National Ambient Air Quality Standards (NAAQS) for the United States of America (U.S. EPA, 2012); WHO guidelines (WHO, 2006) and European Union standard (European Commission, 2008). The target and maximum values set under these legislations can be found in the next section.

FINDINGS AND ARGUMENT

Figure 1 shows the comparison between the daily concentrations of PM_{10} during 5 years of monitoring with air quality standards used as reference. Discontinuity of PM_{10} measurement line (in red) indicates gaps in the monitoring due to equipment maintenance. The maximum average daily concentration of PM_{10} was 87 µg m^{-3} recorded in September 13, 2011.

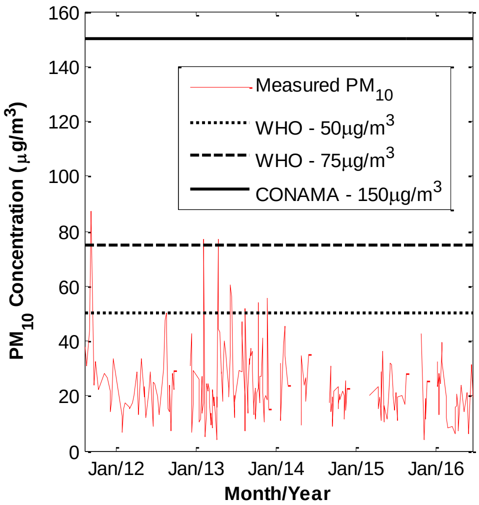

Figure 1. Measured daily concentrations of PM_{10} and comparison with air quality standards.

The daily limit of 150 µg m^{-3} for PM_{10} which is set by Resolution CONAMA N° 003/1990 was not exceeded for the monitoring site. Besides, U.S. EPA states that the primary and secondary standards for PM_{10} should not exceed 150 µg m^{-3} more than once per year for an average over 3 years. Thus, the North American standard for PM_{10} was not violated either. The WHO guidelines and the EU standard (50 µg m^{-3}) allow the daily concentration to exceed the limit by up to 35 occasions during one year. However, in the period of investigation PM_{10} daily concentrations exceed the threshold in 9 occasions. WHO interim target-3 (IT-3) of 75 µg m^{-3} for 24-h concentrations was exceeded three times from 2011 to 2016. The distribution of PM_{10} annual averages is presented in Figure 2. For all years, the limit established by WHO and the final goal set by Decree N° 59.113 for State of São Paulo of 20 µg.m^{-3} was reached. Conversely, the CONAMA N° 003/1990 and EU standards were not exceeded. From to 2011 to 2016 the annual averages of PM_{10} were 32 µg m^{-3}, 22 µg m^{-3}, 26 µg m^{-3}, 23 µg m^{-3}, 20 µg m^{-3}, and 20 µg.m^{-3}, respectively. The historical average of the period (i.e., 2011-2016) was 24 µg m^{-3}. Most of upper outliers occurred in 2013.

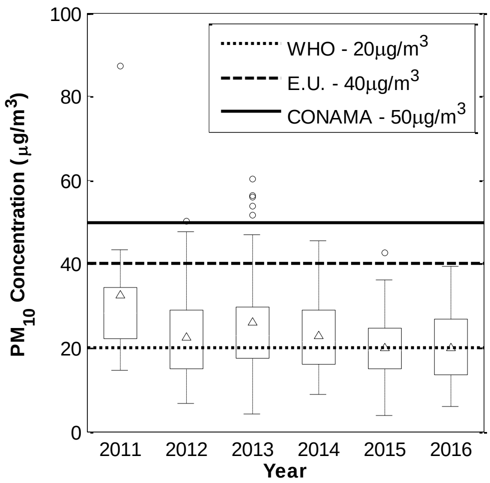

Figure 2. Annual average concentrations of PM_{10}.

To demonstrate the widespread profile of PM_{10} concentrations among the months, we can observe the changes in median values in Figure 3. This monthly analysis shows the highest variation and median value for August (winter). There are relatively different monthly concentration patterns with the narrowest total range observed in March (summer with typically higher precipitation amounts than other seasons). This indicates that meteorological parameters play a significant role.

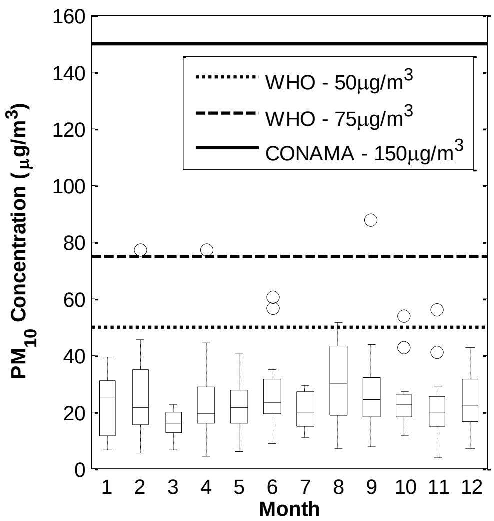

Figure 3. Monthly variability of PM_{10} concentrations.

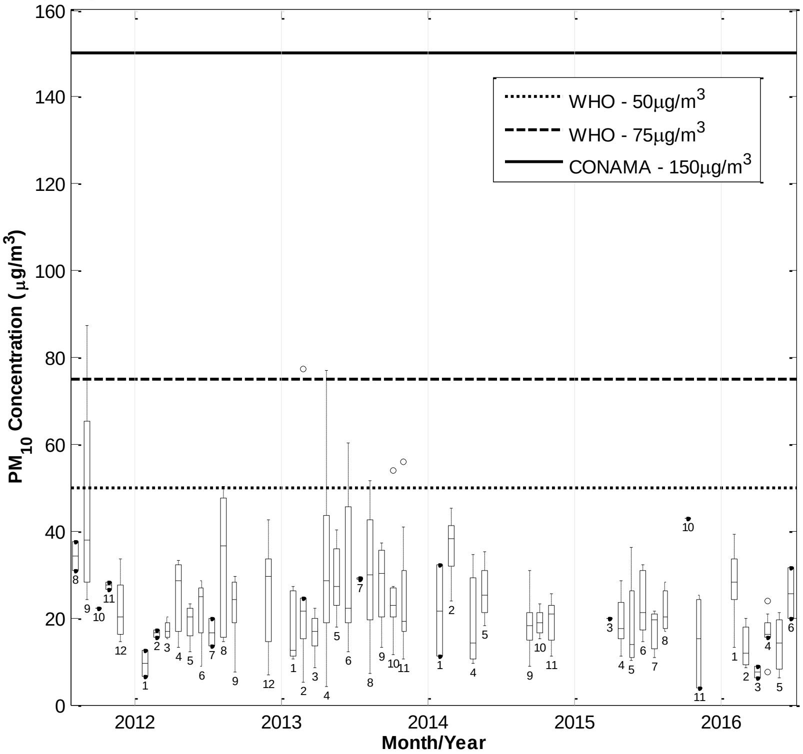

Figure 4. Individual monthly variability of PM_{10} concentrations between August 2011 and June 2016.

To deliver an individual monthly profile of the mass concentrations over the years, we present Figure 4. For 2012, 2013 and 2015 during the colder months and usually lower precipitation rates, greater PM_{10} concentrations were observed. This was not verified for 2015 due to sampling failures and for 2016 because this investigation closes in early winter.

CONCLUSIONS

During the PM_{10} monitoring program conducted from 2011 to 2016 in the city of Florianópolis, the current national standards set for Brazil were not exceeded for both daily and annual limits. Therefore, the air quality in Florianópolis complies with the maximum tolerable levels for PM_{10}. However, WHO annual average guideline is not respected. Accordingly, the concentration levels observed can indicate possible long-term adverse effects of the residents. Further investigations on the influence of meteorological factors can validate the influence of weather conditions in the PM_{10} concentrations. Finally, the reasonable estimate of historical average of PM_{10} can be used as a background concentration for modelling studies in Florianópolis and region.

REFERENCES

ALESP – LEGISLATIVE ASSEMBLY OF THE STATE OF SÃO PAULO. Decree N° 59113 establishes new standards of air quality and provides related measures. São Paulo: Parliamentary General Secretariat, 2013. 17p.

ABNT – BRAZILIAN ASSOCIATION OF TECHNICAL STANDARDS. Atmospheric suspended particulate matter – Determination of the inhalable Particle Concentration by the large Volume Sampler Method Coupled to an inertial Particle Separator. NBR 13412, 1995.

COLLS, J.; TIWARY, A. Air pollution: measurement, modelling and mitigation. 3ªed. New York: Routledge, 2010.

CONAMA – NATIONAL COUNCIL FOR THE ENVIRONMENT. Resolution N° 003, de 1990. Standards on air quality, as provided in PRONAR.

COSTA, M. A. P. M *et al.* Effect of total suspended particles(PTS) on the health of the population of Benfica, Bom Sucesso, Ramos and Manguinhos districts. HYGEIA, Brazilian Journal of Medical and Health Geography. Rio de Janeiro, 2009.

EUROPEAN COMISSION – ENVIRONMENT. Directive 2008/50/EC of the European parliament and of the council – on ambient air quality and cleaner air for Europe. 2008.

JUNENG, L.; LATIF, M. T.; TANGANG, F. Factors influencing the variations of PM10 aerosol dust in Klang Valley, Malaysia during the summer. Atmospheric Environment, v. 45, n. 26, p. 4370-4378, 2011.

M.C. Minguillón, M. Arhami, J.J. Schauer, C. Sioutas. Seasonal and spatial variations of sources of fine and quasi-ultrafine particulate matter in neighborhoods near the Los Angeles-Long Beach harbor, Atmos. Environ., 42 (2008) 7317-7328.

U. S. EPA - UNITED STATES ENVIRONMENTAL PROTECTION AGENCY. Air Quality Criteria for Particulate Matter. 2012.

WHO - WORLD HEALTH ORGANIZATION. Air Quality Guideline. Global update 2005. Copenhagen: WHO Regional Office for Europe, 2006.