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, 27º36'02.2"S, 48º31'05.7"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 Nº 003/1990; final goal set in Decree Nº. 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.](image)

The daily limit of 150 µg.m$^{-3}$ for PM$_{10}$ which is set by Resolution CONAMA Nº 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 Nº 59,113 for State of São Paulo of 20 µg.m$^{-3}$ was reached. Conversely, the CONAMA Nº 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.

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 2. Annual average concentrations of PM$_{10}$.](image)

![Figure 3. Monthly variability of PM$_{10}$ concentrations.](image)
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.

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