Particulate matter, MP10 and MP2.5, indoors and outdoors in classrooms

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1 INTRODUCTION

Atmospheric air quality is directly linked to the concentration of particulate matter (PM) and its size. The World Health Organization (WHO) reported that in 2016, more than 4.2 million premature deaths worldwide (7.6% of all deaths) were partly attributable to air quality compromised by high levels of atmospheric particulate matter (PM) that occur every year (WHO, 2018).

PMs that are in the fraction between 10 and 2.5 are called coarse (PM10-2.5), while PMs smaller than 2.5µm represent the fine fraction, and aerosols with a diameter of less than 0.1µm are part of the ultrafine fraction.

Numerous studies have been conducted to investigate the effect of aerosols on the functioning of biological systems and, in particular, the impact on human health, mainly due to the inhalation of smaller particles. The size of particles is directly associated with their harmful potential to human and animal health (WANG et al., 2015), the smaller the particles the greater the effects.

In the 1970s, with the architectural trend of building sealed buildings for sound insulation, air conditioning and aesthetic issues, an increase in cases of problems related to the air quality of such environments began to emerge (GIODA, 2003). According to the World Health Organization (WHO), more than half of the closed places such as companies, schools, cinemas, homes and even hospitals do not meet their standards. This low quality is caused mainly by poor sanitization of air conditioners and lack of periodic control over possible sources of contamination (WHO, 1998).

PM2.5 is found to contain high concentrations of mutagens (Ando et al., 1996). For example, 79.0-94.5% of polycyclic aromatic hydrocarbons (PAHs) is concentrated in PM2.5 (Sun et al., 1994).

Aerosols in addition to the direct effects on human health, as mentioned above, cause broad economic impacts (VORMITTAG et al., 2018). Exposure to airborne particles has been associated with several diseases, such as: cardiovascular events (POPE et al., 2004; MILLER et al., 2007); lung inflammation by the deposition of particles in the alveoli or bronchi (RAJA et al., 2010); bronchitis;

asthma and other respiratory diseases (CANÇADO et al., 2006); lung cancer (HAMRA et al., 2014); in addition to a more recent association with increased risk of diabetes by exposure to PM2.5 particles (BOWE et al., 2018; RIANT et al., 2018). Another important aspect to be highlighted is the ability of these particles to affect cognitive intelligence, according to a recent study, in addition to other harmful effects on brain chemistry (ZHANG et al., 2019).

The investigation of the emitting origin, the source of aerosols, both from the outside and inside point of view, contributes to mitigating the problem in question, since they represent a serious human health problem, which causes economic impacts, especially the great variability of compounds, mainly those of organic character, with carcinogenic potential, which represent about 10-70% of the mass of the atmospheric aerosol (ALVES, 2005) and make it difficult to investigate their origins.

2 OBJECTIVE

To evaluate the concentration of particulate matter (PM10 and PM2.5) inside and outside the classrooms of IBILCE-UNESP, its correlation with temperature and relative humidity and correlate the data with those found in CETESB - Rio Preto in order to evaluate the working conditions of teachers and students.

3 METHODOLOGY

To carry out the sampling/measurements, the multi-parameter meter, New Air Quality Detector for PM10 and PM2.5 (laser detector), temperature (°C) and relative humidity (RH%) was used. The measurements were conducted at 1.2 m from the floor, approximately the distance between the floor and the nose of the students, in two periods of 4h (morning and afternoon) for 4/5 days a week (First semester 4 days and in the second semester 5 days) (Monday, Tuesday, Wednesday, Thursday and Friday). Sampling was conducted in 6 different classrooms on two levels, first and second floors. For the sampling days, the data provided by the local CETESB station were also collected, for comparison of the same parameters, since the stations are practically at the same height.

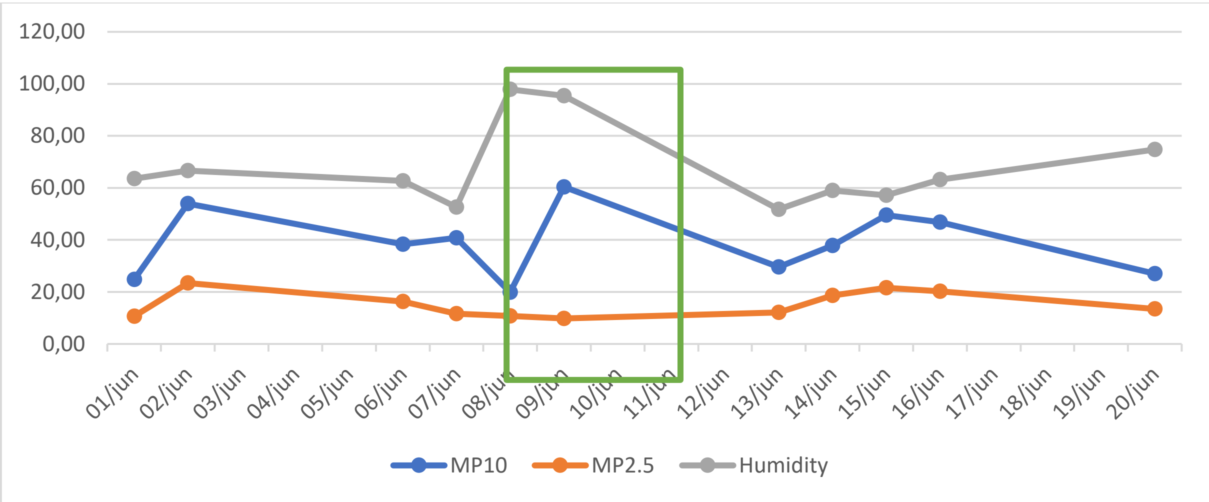
4 DEVELOPMENT

The graphical expressions of the periods are in their entirety, all days were considered, but will not be addressed day by day, but in a general context. The WHO daily average of PM10 and PM2.5 was used for comparison with the data provided by the local CETESB for the same period.

Initially, the correlation between relative humidity (RH%) and the amount of fine particles (PM10 and PM2.5) present in the breathable atmosphere was addressed. Humidity is an important factor that influences the mass of aerosols present in the air. Graph 1 shows the averages of PM10, PM2.5 and RH% values obtained from the CETESB website for the period from May 23 to June 30,

2022. From this graph, it is possible to observe the relationship between humidity and the concentration of fine particles. When the RH% is above 95%, there is a decrease in the level of PM10 and PM2.5, indicating the occurrence of rain. However, when the RH% is below 95%, there is an increase in the concentration of PM10 and a decrease in the concentration of PM2.5. This effect is due to the fact that smaller particles agglomerate to form larger particles in conditions of high humidity but without rain. This phenomenon is particularly evident in the data for 08 and 09/06/2022.

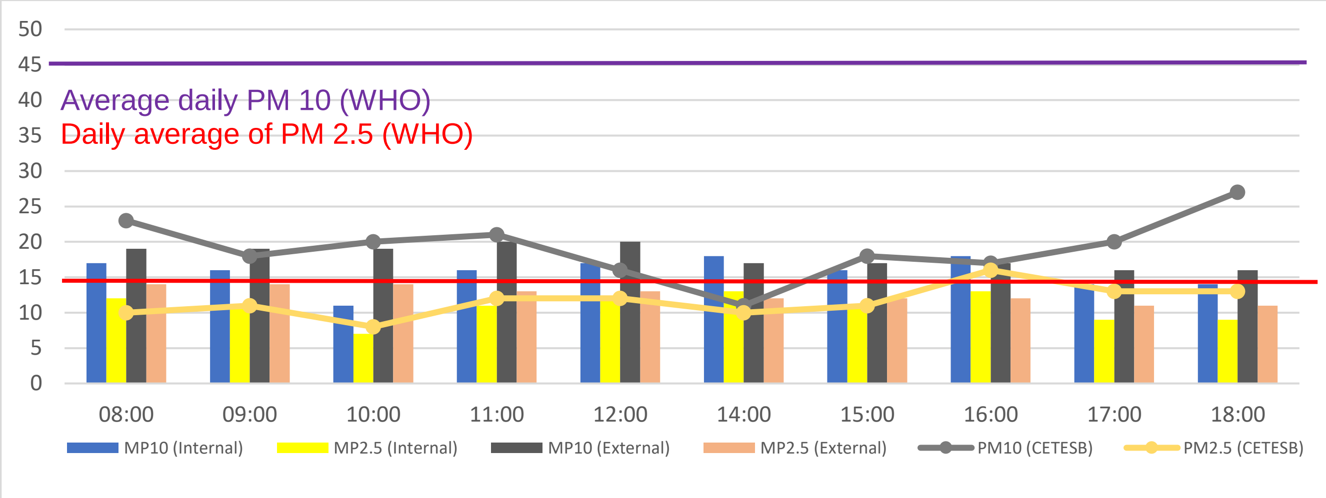
Graph 1. Correlation between Relative Humidity and amount of PM10 and PM2.5, obtained from the local CETESB station.



Source: Own authorship (2022).

After examining the relationships between humidity and the presence of particulate matter, measurements were taken at constant 60-minute intervals on 31/05, as shown in Graph 2. The lunch break was 120 minutes. The objective of these measurements was to evaluate the behavior of particulate matter during a day of academic activities. It was observed that access to the rooms and the movement of curtains and fans affects the level of PM2.5, which tends to reach the maximum limit, decreasing when the room is static during classes, reaching the minimum at 10 am (break). The same behavior is observed in the afternoon. The indoor PM2.5 values follow the CETESB data, except at 2 pm, due to the traffic of students, motorcycles and cars. The maximum values reach 13µg m^{-3} at 9am, 12pm, 2pm and 4pm, which is close to the WHO recommended limit. These results are corroborated by PM10 data, which follow the same trend, suggesting that it is not appropriate for academic activities.

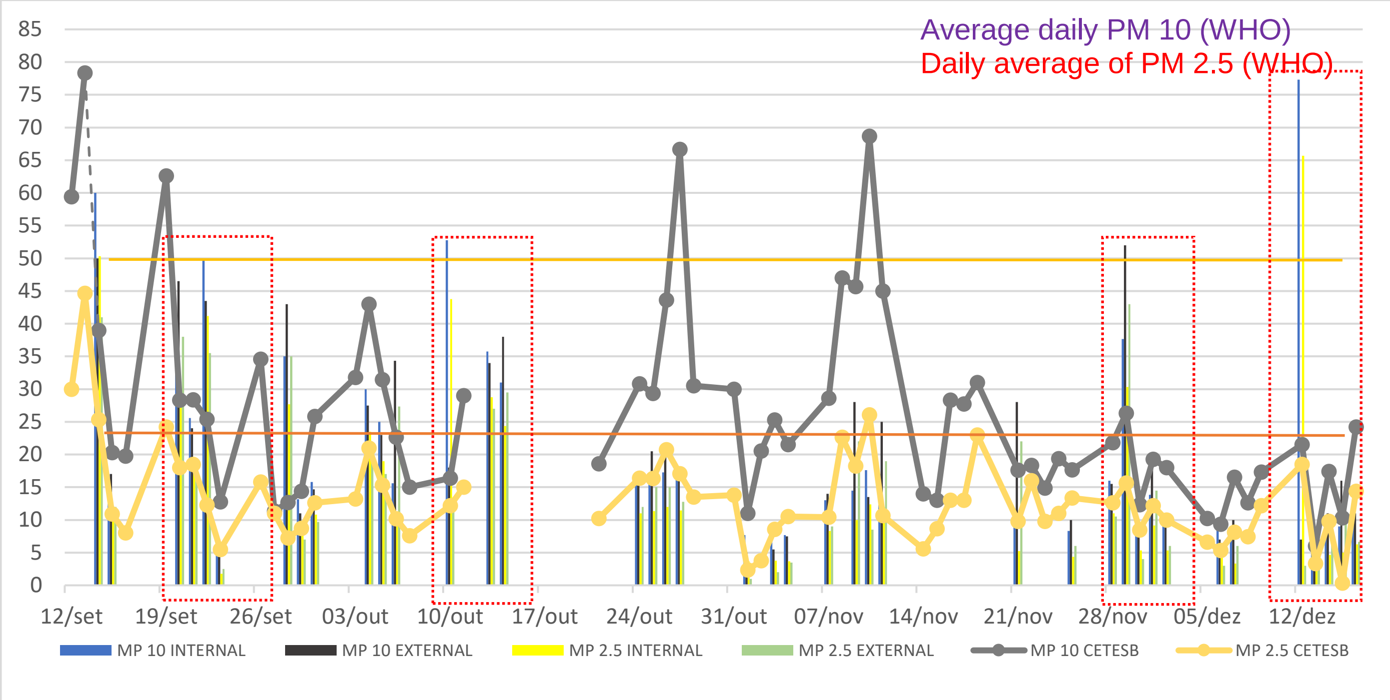
Graph 2. Values of PM 10 and PM 2.5 measurements (Internal/External) obtained every 60 min, compared to CETESB values on 05/31/2022.



Source: Own authorship (2022).

In the second semester, studies were conducted on the presence of particulate matter PM10 and PM2.5 inside and outside the classrooms and the Chemistry Laboratory at IBILCE, Campus of São José do Rio Preto, SP. Graph 3 shows the results of these measurements throughout the semester. The concentrations of PM10 and PM2.5, both indoors and outdoors, mostly remained below the value recommended by WHO, which is 45 µg/m³ and 15 µg/m³, respectively. However, there were exceptions, highlighted in a red box in Graph 3, which may have been influenced by the humid and hot weather of the semester. The observed relationship between particulate matter and humidity may explain these atypical days, as no unusual activities were carried out during the period. Other peaks were observed on specific days, such as on 11/28, when values were well above those of CETESB, due to the cleaning of a green area with a tractor after a rain that broke branches. On 12/12, the increase was observed only inside a classroom, due to a teacher cleaning the eraser with chalk. Although CETESB shows several peaks above the WHO recommended values, the difference can be explained by the location of the station near a busy highway. In addition, there are some gaps in the CETESB data, with days without information recorded, which may be due to maintenance carried out on the collectors.

Graph 3. Average concentrations of PM 10 and PM 2.5 particulates of the semester, external and internal to the academic environment compared to CETESB data.



Source: Own authorship (2022).

5 FINAL CONSIDERATIONS

When evaluating **Graphs 1** to **3** it was evidenced that the presence of internal and external PM10 remains practically below the maximum value recommended by WHO, of 45 µg m^{-3}, throughout the monitoring period, be it in any mode and is in agreement, in general with the values monitored by CETESB. This is an important aspect of air quality for the internal working environment of classrooms.

On the other hand, for the most aggressive particulate to human health and resistant to physical deposition, PM2.5, its values measured inside the classrooms, in frank activity, were very close to the reference value, maximum value, recommended by WHO, of 15 µg m^{-3} . For the measurements inside the classrooms, peak values were observed, one of which was 43.75 µg m^{-3} , approximately 288% higher than that recommended by WHO. The PM2.5 values determined by 60 min intervals pointed to an average value of 8 µg m^{-3}. For the areas outside the classrooms, for long sampling times of PM2.5, several peaks occurred, with values higher than the recommended value of 15 µg m ^{3}.$^{-}$

Thus, in general, the presence of PM2.5 particulates both inside and outside the classroom environment should be treated as a concern since both students and teachers remain in classrooms for hours on end and later in the corridors, to access other classrooms and or their work offices and or laboratories.

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