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PARTICULATE MATTER DISTRIBUTION IN SELECTED PORTUGUESE ARCHIVES: A PRELIMINARY STUDY

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Abstract

Particulate matter (PM) can have a significant impact on human health and on artifacts stored and kept inside museums and archives. To the author's knowledge, its immediate and/or long-term concentrations and distribution on Portuguese archives has never been determined. Four Portuguese archives (with and without HVAC/air filtration systems) were selected and the immediate concentration of airborne particulate matter was measured by active sampling. Indoor-outdoor ratios were also determined. International and national guidelines were used to ascertain the environment's quality, both for the readers and staff and for the documents preserved in these institutions. Inside, PM2.5 ranged between 0.37μg/m^3 and 27.61μg/m^3, while PM10 ranged between 4.43μg/m^3 and 285.52μg/m^3. The lowest values were determined in storage rooms and the highest in reading rooms. In terms of human health, Portuguese guidelines for immediate PM10 concentration were not met in several locations. For conservation purposes, storage rooms were classified according to an original air quality grid. Air filtration systems proved valuable in maintaining a safe environment for our written heritage and the staff and readers that deal with it and care for it every day. This study constitutes the first snapshot of the particulate matter concentrations and distribution in Portuguese Archives.

Keywords: *Archives; Conservation; Documents; Indoor Air Quality; Particulate Matter*

Introduction

Particulate matter (PM), term used for a mixture of solid particles and liquid droplets suspended in the air, is composed of both coarse (PM10, < 10μm) and fine particles (PM2.5, < 2.5μm). The former, under 10um diameter, are a result of mechanical disruption, evaporation of sprays, and suspension of dust and in its constitution one can find aluminosilicate and different oxides of crustal elements [1, 2]. The main sources of these particles include dust from roads, industry, agriculture, construction and fly ash from fossil fuel combustion. Fine particles

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are formed from gas and condensation of high-temperature vapors during combustion and are composed of various combinations of sulfate, nitrate and carbon compounds, ammonium, hydrogen ions, organic compounds, metals and particle bound water [1].

Airborne particulate matter can have damaging effects. Exposure to inadequate levels can lead to adverse health outcomes and material damage, artistic and historical objects included [2]. Several epidemiological studies have linked both PM10 and PM2.5 with significant health problems [3]. Particles with aerodynamic diameter smaller than 2.5μm, correspond to the breathable particle fraction capable of penetrating the alveolar region of the lung and have, according to the US Environment Protection Agency (US EPA), a greater association with mortality and morbidity rates than PM10 [1]. On a mass basis, small particles generally induce more inflammation than larger particles, due to a relative larger surface area [4, 5]. Wheezing, exacerbation of asthma, respiratory infections, chronic bronchitis and (exacerbation of) chronic obstructive pulmonary disease [6] are some of the problems that can arise from inhalation of these particles. Environmental PM2.5 standard levels of 15μg/m^3 (annual average) and 35μg/m^3 (24h exposure) were established by EPA [7]. The WHO went a step further by proposing a 24h limit exposure of 25μg/m^3 for this particulate size [8].

EPA's standards for the PM10 comprehend a 150μg/m^3 level for 24hour average exposure [7]. This level increases the likelihood of respiratory symptoms and worsens existing lung disease as some sources state PM10 may even be more potent to induce inflammation than smaller particles due to differences in chemical composition [9]. Studies have showed that PM10 health effects can be observed with PM10 levels below this value [1] and the air quality guidelines (AQG) proposed by WHO [8] suggest a lower 24h limit exposition of 50μg/m^3.

Because most of the air pollution epidemiology is based on using outdoor measurements of pollutant levels for the analysis of the association between exposures and health outcomes the limits discussed so far refer to the outdoor particle matter concentrations. It is well documented, however, that the average person (in the United States and Europe) spends 15-18 hours indoors (in homes, schools, workplace, etc.) for every hour spent outdoors [10] and similarly, a substantial fraction of mankind is exposed to levels of a number of chemicals and pollutants which are higher indoors than outdoors [11]. This fact makes it of the upmost importance to establish indoor limits for PM but designing indoor data has proven to be a difficult task for the scientific community. According to the WHO [11] there is no reason to assume that health effects would be associated with exposures to these pollutants only in outdoor environments and so this organization suggests an approximation between the outdoor and the indoor levels.

For indoor quality certification purposes, the Portuguese legislation (NT-SCE-02) [12] classifies as non-conformal an indoor environment with immediate [PM10] above 150(±10%)μg/m^3. No limit is established for PM2.5. Lacking alternative relevant data, for PM2.5 the levels proposed by WHO [8] were taken into consideration and applied to the particular indoor environments analyzed in this study since public spaces such as libraries, museums and archives are covered in the existing guidelines [11]. Using the data provided by the WHO [8] (PM2.5 and PM10 AQGs and interim targets-1 of 25/75μg/m^3 and 50/150μg/m^3 respectively) the authors considered 75μg/m3 as the limit for PM2.5.

Although there is still no consensus about limits of exposition for cultural heritage - since the affected materials can be of such diverse origins - it is relatively easy to name the key pollutants. As for human health, PM also takes an important role in conservation and is considered as one of the criteria-pollutants [13]. It is responsible for negative visual effects such as loss of gloss and dull colors as its accumulation onto works of art surfaces can determine soiling [14, 15]. PM can also react with the surfaces on which it settles and the chemical characteristics of particulate matter play an important role in deterioration processes [14, 16, 17]. The organic fraction of this matter can also act as medium or as substrate for microorganism development [17]. Black soot can be particularly detrimental to the margins of ancient books [18].

In opposition to the healing capacity of the human body, valuable objects will accumulate damage from any attack, slowly decaying more and more. In the long run, even the smallest exposure to pollutants will have a cumulative and sometimes autocatalytic effect [13] and objects can remain in an inappropriate environment for decades. This might explain why standards tend to be more stringent towards cultural heritage conservation.

The limits established by the US National Bureau of Standards [19] refer to the PM10 particles and support a concentration below 75μg/m^3 inside general museums. In these institutions, values between 20-100μg/m^3 in busy entrance halls or galleries and less than 10μg/m^3 inside storage or archive areas are presented as typical. More drastic guidelines are proposed by the Italian legislation (MIBAC 2001) where the PM10 values should not cross the 30μg/m^3, even in instant measurements [17].

It is well known that PM2.5 fraction is also important in conservation because of its small particle dimensions and relatively long residence time [20]. Its partial anthropogenic origin is responsible for a complex and potentially dangerous chemical composition since about 10% – 70% of the PM2.5 is made of organic compounds [21]. Carbon fractions are responsible for the soiling and blackening of cultural heritage and soluble acid aerosols, like sulfates, are generally abundant in fine particulate matter [20]. Although no established limits were found for this finer fraction of particulate matter, J. Tétreault [14] proposes a range between 0.1 and 10μg/m^3 for compliance with air quality preservation targets between 100 and 1 year, respectively.

Given the above limits and recommendations, the aim of this study was to perform a primary analysis of particulate matter distribution in archival settings on four distinct Portuguese archives and analyze the results obtained from a health and conservation point of view.

Material and Methods

Between December 2009 and April 2011, particulate matter concentrations were determined with a portable direct-reading equipment (Lighthouse, model 3016 IAQ). Particles concentration measurement was performed for 5 different sizes (PM0.5; PM1.0; PM2.5; PM5.0; PM10) and all measurements were done continuously for five minutes (time mentioned in the NT-SCE-02). The readings were performed in the middle of the rooms and at nose height. Exterior air measurements were used for reference purposes and to establish the inside/outside ratio (I/O).

Active sampling, as performed by the above mentioned equipment, can give to the institution a valuable snapshot of the indoor air quality conditions [19] and, because it is cheaper and easier to install than a passive diffusion method, it can help the institution to assess the need for a more thorough study [22]. Two different sampling seasons (one in winter/autumn and one in summer/spring) were considered for each of the rooms in the four selected archives: Arquivo Distrital de Évora (ADE), Arquivo Histórico Ultramarino (AHU), Instituto de Habitação e Reabilitação Urbana (IHRU) and Torre do Tombo (TT). In all archives the studied rooms included at least one storage room and one working or reading room. The working rooms, in all the archives, refer to the location where staff performs their activities (restoration or other).

ADE archive is located in a two storey building and there are storage rooms in both the first and ground floor. Both reading and working rooms analyzed have windows and are located in the first floor. Besides the two sampling seasons, a third analysis was done in this archive in order to assess the impact of construction work on the PM distribution. There is no HVAC system in this archive.

In the AHU archive the storage rooms are located in the ground floor and basement. The reading room is on the first floor while the working room is located at the ground level. In this archive there is also no HVAC system and there are windows in the reading room and working room.

Although located in an historical fortress, the building that now houses the IHRU collection suffered intensive renovations before becoming an archive. The building relies solely on mechanical systems for ventilation and there are only functioning windows in the reading room.

In terms of ventilation, TT archive is quite similar to IHRU as all ventilation is performed by a mechanical system. Only storage and working rooms were assessed in this archive and there are no functioning windows in any of the analyzed locations.

Using the available guidelines regarding PM10 and the proposed targets for PM2.5, four conservation categories and ranges were considered by the authors [22]: A, B, C and D (Table 1).

Table 1. Proposed indoor air quality categories as defined by PM10 and PM2.5 concentrations. The environment can be classified as A, B, C or D according to these values (average concentrations)

		Conservation Categories and Ranges			
		A	**B**	**C**	**D**
Particulate matter dimensions	PM2.5	<1μg/m^3	1 - 5μg/m^3	5-10μg/m^3	>10μg/m^3
	PM10	<10μg/m^3	10-30μg/m^3	30-75μg/m^3	>75μg/m^3

Regarding PM2.5, J. Tétreault [14] mentions the relevance of preservation targets between 1 and 10 years which are useful and feasible for many museums and the best achievable target for historical buildings. The authors, following these indications, do not consider relevant the attribution of a hypothetical AA level with 0.1 to 1μg/m^3 (corresponding to a preservation target of 100 years).

This classification is not meant as vinculative but can be used as a stepping stone for designing more formal and standardized values. No air quality recommendations are mentioned in the ASHRAE Handbook [18] for both particulate diameters.

The measurements were analyzed from a health point of view for the working and reading rooms while storage rooms were studied considering documents' conservation requirements. Portuguese legislation (to which a PM2.5 limit was also considered) and the air quality grid proposed for document's conservation (Table 1) were used to classify the evaluated environments.

Results

The results are presented separately for each of the archives. Figures 1 to 5 show the PM2.5 and PM10 concentrations in two different seasons and for the locations sampled in each of the four selected archives. Also pointed out in the figures are the locations with higher than 1 indoor/outdoor particle concentrations ratios (I/O).

The levels were, in general, higher in February for both particle diameters. The exception was Storage Room 1 where levels for both PM2.5 and PM10 were higher in September. Also in terms of I/O ratio, the scenario was worse in February with more locations presenting a higher-than-one ratio. For PM2.5, the lowest value (6.71μg/m^3) was obtained in Storage Room 1 in February and the highest (25.00μg/m^3) in the Reading Room that same month. For the PM10, the same rooms also present the lowest and highest value: 23.25μg/m^3 in Storage Room 1 and 238.78μg/m^3 in the Reading Room.

A third data collecting season was performed for this archive during construction work taking place in the first floor where all the rooms but Storage Room 1 are located. The institution remained functioning during this period and the storage rooms were kept closed.

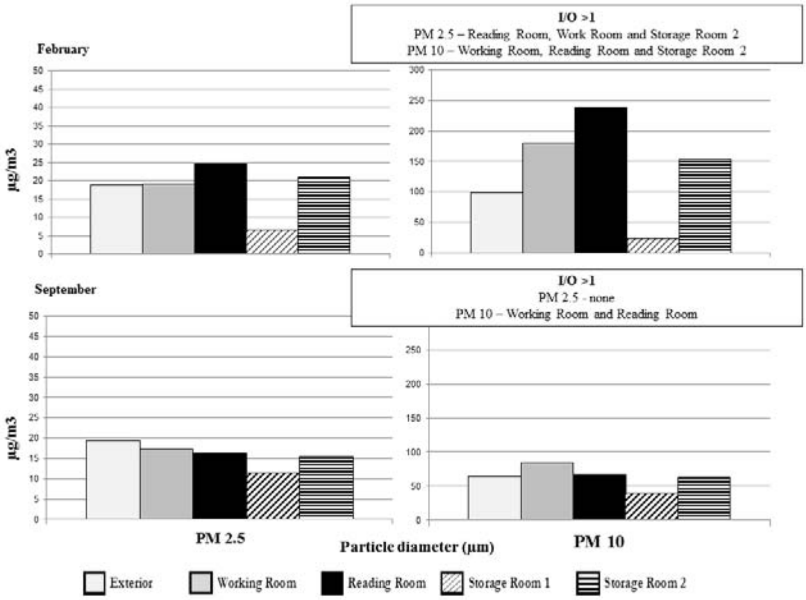

Fig. 1. Immediate particulate matter concentration (µg/m^3) in the four rooms selected in ADE archive for PM2.5 and PM10. Two seasons were considered. Please note the different scales used for PM2.5 and PM10.

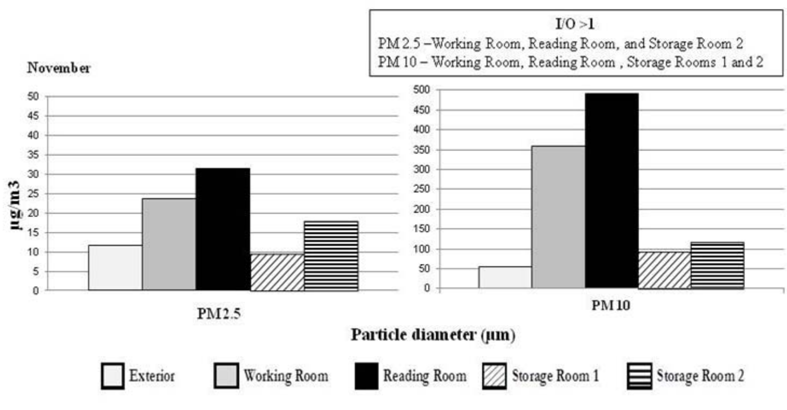

Fig. 2. PM2.5 and PM10 particle distribution during construction work on ADE archive. Note the scale for PM10 is now 500µg/m^3.

As expected, the particulate matter concentrations were much higher for both diameters considered. The I/O was superior to 1 in almost all of the rooms (except for Storage Room 1, ground floor, for PM2.5) and the highest values now reached the 31.45µg/m^3 in the PM2.5 range and 491.41µg/m^3 in the PM10 range. Indoors, the lowest values in the PM10 and PM2.5 fractions were 91.58µg/m^3 and 9.38µg/m^3, respectively.

In the AHU archive the concentrations were generally higher in April, exception made to the working room for the PM10 fraction. However, in terms of I/O ratio, the scenario was worse in December with more locations presenting a higher–than-one ratio.

For PM2.5, the lowest indoor value (3.53μg/m^3) was obtained in Storage Room 1 in December and the highest (27.61μg/m^3) in the Reading Room in April. For the PM10, the values ranged between 33.74μg/m^3 in Storage Room 1 in December, and 285.52μg/m^3 in the Reading room, in April.

In the IRHU archive, the concentrations were considerably higher in April. Exception made to the Working Room 1 for the PM10 fraction which remained stationary.

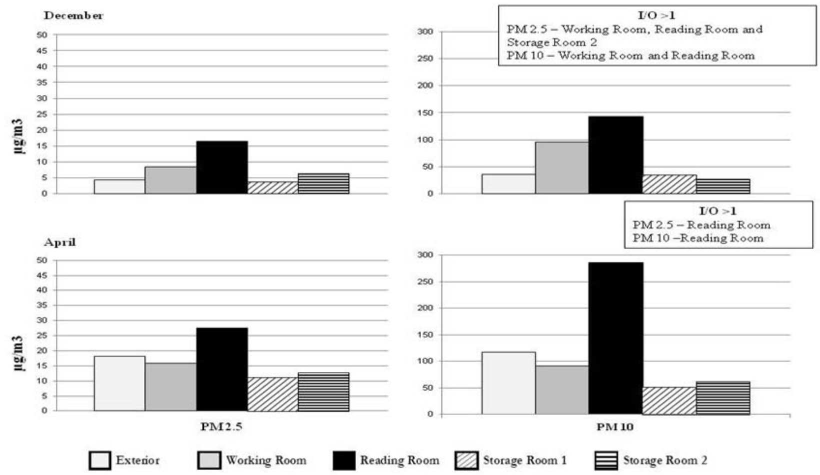

Fig. 3. Immediate particulate matter concentration (μg/m^3) in the four rooms selected in AHU for PM2.5 and PM10. Two seasons were considered. Please note the different scales used for PM2.5 and PM10.

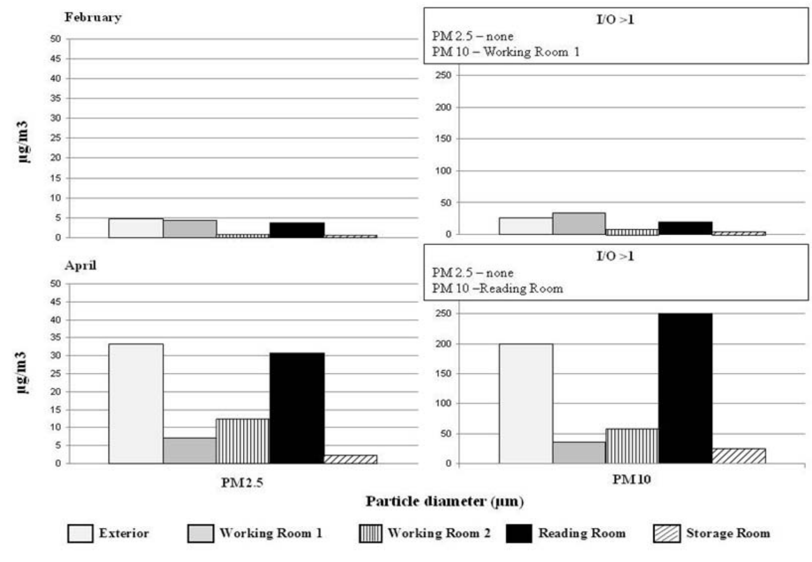

Fig. 4. Immediate particulate matter concentration (μg/m^3) in the four rooms selected in archive IHRU for PM2.5 and PM10. Two seasons were considered. Please note the different scales used for PM2.5 and PM10.

For PM2.5, the lowest indoor value (0.37μg/m^3) was obtained in Storage Room 1 in February and the highest (30.67μg/m^3) in the Reading Room in April. For the PM10, the values ranged between 4.43μg/m^3 in the Storage Room (February) and 250.79μg/m^3 in the Reading Room (April).

TT archive presents lower concentrations than the other archives and no undesirable I/O ratio was observed.

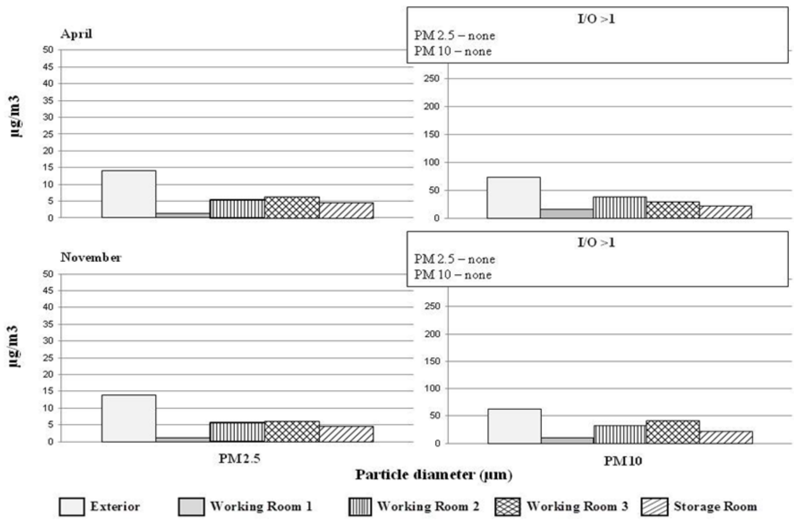

Fig. 5. Immediate particulate matter concentration (μg/m^3) in the four rooms selected in archive TT for PM2.5 and PM10. Two seasons were considered. Please note the different scales used for PM2.5 and PM10.

For PM2.5, the lowest indoor value (1.26μg/m^3) was obtained in Working Room 1 in April and the highest (6.16μg/m^3) in Working Room 3 in that same month. For the PM10, the values ranged between 10.413μg/m^3 in Working Room 1 (November) and 40.06μg/m^3 in the Working Room 3 (November). Between the two seasons, the inside levels show a very small difference for both particle diameters considered.

Discussion

In all of the archives studied and for both seasons, the PM2.5 concentrations were generally lower than the PM10 concentrations. The highest outdoor PM2.5 (33.14μg/m^3) and PM10 (199.06μg/m^3) concentrations were registered around IHRU in April and the lowest around AHU (December, 4.17μg/m^3) and IHRU (February, 26.54μg/m^3), respectively. International guidelines establish a 35μg/m^3 environmental limit for PM2.5 and this value, although determined for only five minutes in our study, was never crossed. In urban areas, the reference concentration for PM2.5 ranges between 1-100μg/m^3 [18] and the mean value was of 11.9μg/m^3 in Lisbon in 2008 [23]. The annual PM10 mean value for Lisbon for that same year was 30μg/m^3 [23].

Though ADE and IHRU are geographically more protected from air pollution, all archives are considered urban and present similar levels of particulate matter.

In spite of the possibility of finding workers and readers inside the storage areas these will be evaluated from a conservation point of view while the evaluation of both working and reading rooms will be based on health/human comfort guidelines.

Working and Reading Rooms

According to the Portuguese legislation presented earlier, inside PM10 concentration should not be higher than 150μg/m^3. The authors proposed a 75μg/m^3 indoor limit for PM2.5.

Both particulate diameters' concentrations were never exceeded in TT which possesses an HVAC system with particulate filtration. Also the I/O ratio never reached the unity in this Archive due to these efficient systems that deem almost equal the results obtained on both seasons.

For all the remaining archives, the PM2.5 established limit was never crossed in any of the rooms studied. In fact, most of the rooms showed values lower than 25μg/m^3, which may indicate that it is possible to pursuit values lower than 75μg/m^3. The higher than 1 I/O ratio verified in the reading rooms of both ADE (February) and AHU (both seasons) can actually be expected for the PM2.5 fraction since it usually presents a marked organic composition [24] and these rooms have a strong human presence. In the IHRU archive, the reading room, although not presenting an I/O above 1, also presented a higher concentration than 25μg/m^3 a result probably linked to the outside concentration which was also very high. No reading room was analyzed in TT archive and this could explain why all the results obtained in this Archive were below 25μg/m^3.

Regarding PM10, the 150μg/m^3 Portuguese air quality legislated maximum was exceeded in at least one location and season in archives ADE, AHU and IHRU.

In April, AHU registered the highest PM10 value indoors in the Reading Room (285.52μg/m^3) a value that is certainly related to the outside value registered which was also abnormally high (117.06μg/m^3). This dependence relies on the characteristics of this room which has several windows and does not possess any filtering system. Similar high values for PM10 and reading rooms were also found in IHRU (250.79μg/m^3) and ADE (238.78μg/m^3). In ADE the reasons are very similar to AHU while in IHRU the question is not so much the windows but the proximity to the archive's entrance coupled with a lack of a filtering system for this room in particular.

In the working rooms the limit of 150μg/m^3 was also crossed. ADE had a PM10 value of 180.14μg/m^3 in February and presented an I/O ratio above 1. While this value was lower in September the inadequate ratio remained. The working room in AHU did not cross the legislated limit but its similar values and opposing I/O ratios in both seasons suggest a PM10 distribution independent from the outside profile and related to the activities developed in the room. In IHRU only working room 2 seems to have been affected by the outside values since it showed much lower values when the outside concentration was also lower.

Regarding the construction work that took place in ADE archive, the PM2.5 suffered almost no noticeable changes, an expected scenario since this sort of activity is responsible for a large increase in the coarse fraction of the particulate matter spectra. This increase was very marked in the PM10 range with a 425% and 734% increase in the Working and Reading Rooms, respectively, when compared with the results obtained two months earlier. This increase was less abrupt when compared with the first season but still represented a 200% increase in both rooms. In an attempt not to disrupt the institution's normal functioning, the Archive was kept open and running during construction works.

The percentual distribution above and below legislated values for the PM10 determinations is presented in table 2.

Table 2. Percentual distribution of the assessed rooms (Reading and Working Rooms) for the PM10 fraction as they were above or below legislated values

	PM10 Percentual Distribution	
ARCHIVE (number of rooms assessed)	**0-150μg/m³**	**>150μg/m³**
ADE (2)	50%	50%
AHU (2)	75%	25%
IHRU (3)	83%	17%
TT (3)	100%	

The natural ventilated archives performed worse in terms of providing a good protection from PM10 particulate matter. It is noteworthy, however, that no reading room was assessed in TT and it was in this room that the other archives performed the worst.

Storage Rooms

As mentioned earlier, and despite their importance, there are no established conservation limits for the PM2.5 fraction of the particulate matter but the authors propose an environment rating based on the limits set by J. Tétreault [14]. The authors acknowledge the need for a broader study period but consider these results as good indicators since storage rooms are seldom open, cleaned thoroughly or frequented by users or staff and the presented values are less likely to vary greatly in more prolonged measurements.

As happened before, Archives IHRU and TT present the best results. Natural ventilation, with no filtering system deems less optimal the conditions provided in the first two archives.

Regarding PM2.5, for a preservation target of 100 years - meaning a minimal risk of deterioration during this time period - archives should aim at levels of 0.1μg/m^3 [14]. Realistically, museums and archives can aim for a 10 year preservation target and for this time period maximum levels should not cross one unit. Only one result corresponded to these criteria: IHRU with 0.37μg/m^3. The highest value obtained in this archive was 2.14μg/m^3 which is not only a very good result in terms of air quality target as it was recorded when a high outdoor [PM2.5] was registered. PM2.5 concentrations in TT were very similar in both seasons (4.47 and 4.46μg/m^3) and also mirror the effort made in terms of air filtering for small particles. Both in IHRU and TT no higher than 1 I/O ratios were determined for the storage rooms.

The other two archives, with no filtering systems, presented higher levels, most of them above the 10μg/m^3, which diminishes considerably the amount of time needed for change (and potential damage) to occur. In ADE archive values reached 21.02μg/m^3 in Storage Room 2 in February. As already mentioned, these values were not significantly altered during construction work.

In archive AHU values were also higher than TT or IHRU and reached a maximum of 12.52μg/m^3. In both storage rooms the levels recorded at the second season (April, 2011) were, however, more than 50% higher than the ones recorded in December. This clear increase in concentration might be related to the outdoor higher PM2.5 fraction also detected.

Regarding PM10 and according to the US Standards, the Archival reading for PM10 particulate concentration in UK is, typically, below 10μg/m^3 [19]. In the Archives studied this value was only attained in February in the IHRU archive (4.43μg/m^3). All the other storage rooms showed higher values and the highest was recorded at the ADE's Storage Room 2 (153.25μg/m^3). This archive presented one reading higher than 75μg/m^3, a number considered as a conservation limit for general museums. None of the remaining storage rooms crossed this value. Using the Italian guidelines, where the limit is crossed at 30μg/m^3, only TT and IHRU's storage rooms resented values within the limits during both seasons.

During construction work in ADE, the values for PM10 suffered a sharp increase in storage room 1 where now the ratio was higher than 1. For storage room 2 the increase was only noted when compared to the values obtained in September but, again, the I/O ratio was only altered for this storage room in the third season. While after this activity all the functional spaces will suffer an intense cleansing procedure, it is quite difficult to perform a thorough work in the deposits where hundreds of documents are kept. In Storage Room 2 the documents are mostly kept in archival boxes and these act like a barrier between the documents and the outside environment (according to the UK guidelines, the PM concentration is negligible in these boxes) but in Storage Room 1 part of the documents are unprotected and the particulate matter will settle on them and contribute to their soiling and deterioration.

Tables 3 (PM2.5) and 4 (PM10) show the room distribution according to air quality provided.

Table 3. Environment classification of the storage rooms for the PM2.5 fraction

	PM2.5 Ranges for Conservation Purposes			
ARCHIVE (number of rooms assessed)	**A** **<1μg/m³**	**B** **1-5μg/m³**	**C** **5-10μg/m³**	**D** **>10μg/m³**
ADE (2)			25%	75%
AHU (2)		25%	25%	50%
IHRU (1)	50%	50%		
TT (1)		100%		

In line with previous results, both IHRU and TT present very good PM2.5 percentual distributions with preservation targets between 10 and 5 years. The non-HVAC archives showed higher concentrations and some of their results are class C and D which assure less than a year of minimal damage.

Table 4. Environment classification of the storage rooms for the PM10 fraction

	PM10 Ranges for Conservation			
ARCHIVE (number of rooms assessed)	**A** **< 10μg/m³**	**B** **10-30μg/m³**	**C** **30-75μg/m³**	**D** **>75μg/m³**
ADE (2)		25%	50%	25%
AHU (2)		25%	75%	
IHRU (1)	50%	50%		
TT (1)		100%		

The control of the coarser particulate fraction is vital for the maintenance of the finer particulate levels [14] and the results shown in tables 3 and 4 reflect this strong correlation. Expectedly, TT and IHRU deliver better results and have all their storage room below the Italian guidelines. ADE, on the contrary, crosses the conventional limit of 75μg/m^3 in one of the measurements taken and was closely followed by AHU, with more than half of the rooms falling in the C category.

According to the WHO, sulphate and organic matter are the two main contributors to the annual average PM10 and PM2.5 mass concentrations [4]. On documents and leather covers - as the ones that can be found in the studied settings - sulphate can damage paints and dyes and embrittled and discolor papers [19]. Additional studies are required to determine if this component is present in the indoor environments analyzed. Organic matter is a substrate for biological deterioration and comes to add to the already susceptible matter that composes books and documents in general.

Conclusions

This study represents the first snapshot of particulate matter concentration and distribution in Portuguese archives and was focused on both the health concerns for those who attend and work on the premises and the conservation needs of the documents and valuable written heritage.

Following national and international standards and guidelines, it was possible to determine concentrations higher than desired in both reading/ working rooms and storage rooms. According to different guidelines a set of conservation quality levels for PM10 are proposed [22] and a quality/control level grid created for both PM10 and PM2.5 [22].

In terms of ventilation/filtration systems, the benefits of the mechanical systems were obvious with much better results in terms of PM concentrations and indoor/outdoor ratios.

Since PM concentration in the indoor environment can be variable in time and space due to influencing factors like the activities of users and airing [25] a more prolonged study with continuous monitoring of both PM10 and PM2.5 was advised for the working and reading rooms. This procedure, though more expensive, can add relevancy to the data obtained. Some of these data are, nevertheless, unquestionably inadequate since, in any immediate reading and for PM10, Portuguese legislation does not support a PM10 higher than $150\mu g/m^3$ and Italian conservation standards do not recommend an immediate value higher than $30\mu g/m^3$. Because storage rooms are seldom open, cleaned thoroughly or frequented by users or staff the values presented here are less susceptible of change than the reading and working rooms and should be fairly accurate.

Also of relevance were the data obtained after construction work took place in one of the archives and how this activity altered the PM concentrations, despite all the careful sealing of storage rooms. Due to the large amount of documents and archival material kept at these storage units, the thorough removal of any soiling is very unlikely and the unprotected documents will inevitably suffer the consequences of the deposition of this added particulate matter.

Due to the different composition of these particulate matter contaminants, further investigations are needed, in order to determine and cross-check the composition of indoor particles and their toxicological properties as these can be of great importance for both humans and document's preservation.

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