Research on Literary and Art Development
2025, VOL. 6, NO. 1, 72-75
DOI: 10.47297/wsprolaadWSP2634-786517.20250601

Preliminary Study on Environmental Dust Particles in Cultural Heritage Preservation

Chunzi Wen, Jiayi Tian, Yali Wang, Ting Yang, Er Wang

Sichuan Provincial Institute of Cultural Relics and Archaeology, Chengdu, Sichuan, 610041

ABSTRACT
As global attention to cultural heritage protection grows, the conservation of cultural relics has become a critical means of preserving historical memory and cultural diversity. Dust, as a common particles in the environment, poses a threat to the preservation and display of artifacts. This study aims to explore the current research about the environmental dust particles in the field of cultural heritage preservation and propose corresponding control strategies. First, this paper defines and anlyzes the basic concepts of dust particles, including its definition, sources, and characteristics. Next, it elaborates on the direct and indirect impacts of dust deposition on artifacts, and in response to its persistence and slow emergence, proposes targeted environmental control and daily maintenance strategies, such as improving the surrounding environment, using protective facilities and air purification equipment, and regularly cleaning and controlling visitor flow.

KEYWORDS
cultural heritage protection; environmental dust particles; cultural heritage; particulate pollution; control strategy

1 Introduction

Cultural heritage protection refers to the preservation, restoration, and management of cultural relics with historical, artistic, and scientific value through scientific, technological, and managerial means, to maintain their authenticity and integrity, and prevent damage caused by natural or human factors. Cultural heritage protection is an important avenue for inheriting civilization and promoting culture, as well as a key method for safeguarding national historical memory and cultural diversity. Dust refers to particles that naturally fall to the ground under atmospheric conditions due to gravity.[1]It is widely present in nature. As material remains, artifacts will continuously accumulate dust on their surfaces without human intervention, with a widespread and long-term effect. On one hand, dust covers the surface of artifacts, affecting their aesthetic value; on the other hand, under certain conditions, dust can chemically react with artifacts, leading to or exacerbating their deterioration. For example, Huang Jizhong and his team[2] studied the influence of dust on the stone carvings of Yungang Grottoes, and it was concluded that dust would accelerate the interactional results on stone carvings from physical weathering and chemical weathering, leading to severe weathering. Mou Wei[3] conducted the phenomenal analysis of dust in the storage room of the museum and found that there were a large number of acidic substances in the dust, which would lead to paper acidification and promote the decomposition of cellulose. Shan Zhongwei and his collegues [4] conducted a survey about dust deposition on the surfaces of murals and sculptures at the Mogao Caves, which showed that dust deposition primarily affects the protection of murals and sculptures through three main aspects: physical covering and erosion leading to changes in regional coloration, potential salt attack from soluble salts, and exacerbation of some damage due to serving as a microbial carrier. In summary, dust is an important factor that must be addressed in cultural heritage preservation,. In terms of dust particles in the environment, this paper analyzes the current research achievements and challenges, and proposes preventive measures and control strategies to reduce the impact of dust particles on artifacts, which holds significant practical importance.

2 Basic concepts of environmental dust particles

2.1 Definitions and sources

Under air environment conditions, the particles that fall to the ground by gravity are called dust. The particle size is mostly above 10μm and below 350μm. The unit of measurement index is the amount of surface sediment on a unit area in a certain time, generally expressed as $g \cdot cm^{-2} \cdot d^{-1}$perhaps $t \cdot km^{-2} \cdot 30d^{-1}$. According to the visibility during descent, atmospheric dust can be divided into dust from sandstorms and non-sandstorm conditions. The former includes dust storms, sand lifting, and floating dust events. Based on wind strength at the time of descent, it can be categorized as windy or windless dust. Depending on precipitation conditions during descent, it can be classified as dry or wet dust. Dust sources can be divided into natural and anthropogenic categories. Natural sources mainly include soil, surface sediments, volcanic dust, and pollen or spores from the biological world. Anthropogenic sources primarily consist of industrial dust generated by processes such as mining and open-pit quarrying[1][5] .

For the environment of cultural relics, the dust sources for immovable artifacts mainly consist of primary particles from natural sources and primary and secondary particles from anthropogenic sources. For movable artifacts, which are generally stored in artificial environments, the dust sources are primarily secondary particles from anthropogenic sources. Considering the relatively small spatial scale for artifacts storage, apart from atmospheric dust caused by regional factors, other important factors affecting the quantity and sources of dust particles include visitor activities and whether there are construction projects or major traffic routes nearby[2] .

2.2 Characteristics

At present, samples for dust particles research are directly collected from the surface of artifacts or other objects in the storage and the filter nets[3][4][8]. Some references include the *Ambient air—Determination of Dustfall—Gravimetric method* (GB / T 15265—1994)[9-10] released and implemented in 1994 and the *Ambient air—Determination of Dustfall—Gravimetric method* (HJ 1221—2021) released and implemented in 2021[11-12]. The sources, transmission mechanism and influence of dust particles on cultural relics can be inferred through the analysis of its physical and chemical properties.[2-4][7][12]

Dust deposition rate refers to the amount of dust deposited per unit area in a unit time[5].Through analysis, it can be determined that the dust deposition in the storage environment varies within certain ranges and over time. Typically, dust deposition in these environments is higher in the north than in the south, outdoors than in semi-enclosed indoor spaces, and fully enclosed indoor spaces. These facts allow further analysis on the impacts of dust deposition on the chromacity or appearance of cultural relics, as well as an evaluation of different environmental control strategies for protecting cultural relics. The composition of dust particles is closely related to the dynamic conditions during atmospheric transport. Generally, the transmission mechanism can be analyzed based on the average particle size and its distribution range, which helps infer the source of the dust[5].

The mineral composition, elemental composition and magnetization rate of dust from different sources are significantly different[12]. Dust from the crustal source is mainly composed of quartz, feldspar, calcite, dolomite, etc., however, the exact composition of any dust particles depends on the nature of the material in the source area[5] . In addition, the dust from anthropogenic sources is relatively darker in color than that from crustal sources, and generally better in grinding degree[5][7] .The source analysis of dust particles can help to provide the basis for the formulation of environmental control strategies in the preventive conservation of cultural relics.

The spatiotemporal distribution of dust deposition is closely related to wind. For instance, dust deposition increases significantly during sandstorms, with particles traveling longer distances, whereas in calm weather conditions, the opposite occurs. On a temporal scale, dust deposition peaks in spring, followed by summer, with relatively lower levels in autumn and winter. On a larger spatial scale, the closer to the source area, the higher the dust deposition. On a smaller spatial scale, dust deposition is significantly influenced by topographical features; areas prone to dust accumulation are often enclosed lowlands, rough plains, and windward slopes[1] .In the preservation environment of cultural relics, due to the irregularity or roughness of the surface of cultural relics, dust is easily adsorbed and accumulated, which is generally manifested as the vertical direction of surface dust deposition is much lower than the horizontal direction[4].

3 Influence of dust deposition on cultural relics

Dust deposition affects cultural relics in two aspects: direct and indirect. Direct effects manifest as physical and chemical actions, primarily through covering, compressing, and corroding. Indirect effects include providing a habitat for microorganisms, leading to microbial damage, and causing secondary damages during the cleaning process.

First, dust settles on the horizontal surfaces of cultural relics due to its own gravity, while a small portion adheres to vertical surfaces due to electrostatic forces and friction. The accumulation of dust can obscure surface information of the artifacts. Dust particles are mostly angular in shape and can wear down the artifacts surface as they move with air currents. Physical covering and abrasive effects can cause changes in color within areas, which is detrimental to artifact display. If the artifact itself has some damages, especially for more fragile materials like murals, once dust enters these pre-existing damage gaps such as flaking or cracking, it will further compress under the influence of gravity, leading to the peeling of pigment layers[4] .Secondly, dust contains soluble salts and acidic substances, which will directly chemically react with cultural relics. For example, the moisture and soluble salts carried by the dust can cause water-salt migration on the surface and body of stone or earthen cultural relics. Acidic substances can corrode the surface of the relics, leading to problems such as flaking, efflorescence, and peeling[2][4][10][12] .In addition, the dust structure has more pores and a large specific surface area, which is easy to provide a habitat for microorganisms, thus inducing microbial diseases and leading to mold growth or even decay of cultural relics[6]. .In the process of cleaning dust, mechanical operations or other chemical means involved will also cause some wear or erosion of cultural relics, resulting in secondary damages[4].

Currently, an increasing number of experts and scholars in the field of cultural relics are paying attention to the impact

of dust on artifacts. However, since dust is ubiquitous in nature and has a long-term presence, its effects on artifacts only become apparent over time, demonstrating a slow emergence. At present, in the daily maintenance and preservation of cultural relics, there is still a low level of attention to dust, and there is a lack of scientifically sound intervention methods.

4 Dust Reduction strategies

In view of the long-term and slow emergence of dust particles ' effect, the prevention and control strategies of dustfall in cultural relics preservation mainly focus on environmental control and daily maintenance, aiming to reduce the long-term damage of dust to cultural relics.

From the perspective of environmental control strategies, on one hand, it is necessary to address the issue at its source and reduce significant human-induced impacts on cultural relics. After long-term monitoring and tracing of dust sources, if human influence is substantial, consider relocating pollution sources downwind of the cultural relics. Additionally, avoid setting up major traffic routes or large construction sites near the relics. If this cannot be avoided, strictly follow the requirements of environmental protection departments to implement measures that minimize industrial emissions, transportation, and construction-related dust. On the other hand, efforts should focus on controlling the transmission mechanisms of dust, such as establishing green belts around cultural relics to utilize vegetation for dust absorption[14] . Artifacts can also be placed in a closed or semi-closed environment, such as protective covers, exhibition halls or storage rooms, to reduce the exposure of artifacts to the natural environment. In addition, air purification equipment can be equipped to filter particulate matter in the air, which can effectively reduce the amount of dust.

From the perspective of daily maintenance, cultural relics exposed to the air should be cleaned regularly to avoid long-term accumulation of dust. At the same time, scientific methods should be adopted in the cleaning process to avoid secondary damages to cultural relics. Also, the flow of tourists should be controlled to avoid dust pollution caused by human factors[4]. In addition, the protection of cultural relics requires establishing and implementing a collaborative conservation mechanism. First, there needs to be greater emphasis on dust reduction in awareness, enhancing understanding of its hazards, and strengthening top-level design. Specific standards and operational guidelines for dust monitoring and protection should be formulated based on the characteristics of different types of cultural relics, ensuring that conservation work is conducted according to established procedures. Second, basic research should be strengthened, with the development of relevant technologies. This includes conducting laboratory studies on the impact of dust particles on cultural relics, simulating long-term damage under various environmental conditions, and proposing suggestions for improving protective measures. At the same time, dust monitoring equipment should be developed[15] . Strengthen data collection in the preservation environment of cultural relics to provide data support for proposing targeted protection strategies. Through the above strategies, the direct and indirect damage of dust to cultural relics can be effectively reduced, the preservation life of cultural relics can be extended, and their historical, artistic and scientific values can be maintained.

5 Conclusion and outlook

5.1 Conclusion

This paper mainly discusses the issue about the environmental dust particles in the field of cultural heritage preservation, and the conclusions are as follows:

(1) Dust particles have long-term effect and would not be noticed shortly, which have a wide and far-reaching impact on cultural relics. It is mainly reflected in covering the surface information of cultural relics, affecting the aesthetic value, causing cultural relics to suffer from diseases through physical and chemical reactions, and accelerating the deterioration of cultural relics.

(2) The sources of dust are diverse and complex, and their characteristics are closely related to the surrounding environment. For different cultural relics or regions, there are significant differences in the sources, dust amount, impact on cultural relics and transmission mechanism of dust.

(3) Environmental control and daily maintenance are key to dust reduction. By improving the environment around cultural relics, setting up protective facilities, and equipping air purification devices, the long-term damage caused by dust can be effectively reduced. At the same time, regular cleaning of the surface of cultural relics and reasonable control of visitor flow are also necessary maintenance measures.

5.2 Outlook

Future research on dust reduction will focus on the detailed fundamental studies of dust sources and components in

the field of cultural heritage, exploring the mechanisms of interaction between dust particles and artifacts. In terms of prevention and control technologies, new eco-friendly materials and intelligent monitoring systems should be developed to achieve real-time monitoring and precise protection against dust. Policy-wise, specific standards and policies for dust suppression will be established to promote interdisciplinary collaboration and public participation, reducing dust generation at the source to ensure the long-term preservation of cultural heritage.

References

[1] Wang Zanhong. Atmospheric dust deposition monitoring research [J]. Resources and Environment in Arid Areas, 2003(1):54-59.

[2] Huang Jizhong, Zhang Junfang. Study on the Influence of Dust on the Stone Carvings of Yungang Grottoes [J]. Cultural Relics Protection and Archaeological Science, 2004(1):1-8.

[3] Mu Wei, Jin Pu Jun, Nan Pu Heng. Dust detection and analysis in the storage room of Xi an Stele Forest Museum [J]. Cultural Museum, 2015(2): 92-95.

[4] Shanzhongwei, Cui Qiang, Yin Yaopeng, et al. Investigation of surface dust deposition in Mogao Grottoes mural sculptures [J]. Cultural Relics Protection and Archaeological Science, 2023,35(1):127-137.

[5] Li Jinchang, Dong Zhibao. Progress and Prospect of Atmospheric Dustfall Research [J]. Resources and Environment in Arid Areas, 2010,24(2): 102-109.

[6] Zhang Xingqun, Zhang Zhijun, Zhang Xiaorong. Investigation of Qin Terracotta Molds and Its Hazards [J]. Cultural Museum, 1999(1):76-80.

[7] Zhao Yixin, Wang Anjian, Zhang Jun, et al. Study on the surface dust characteristics of Nanxiangtang Grottoes and its influence on stone carving [J]. Environmental Science Research, 2002(6):12-16.

[8] Lu Xuan, Zhang Qunxi, Wang Liqin, et al. Analysis and Research on Dust-Reducing Components in the Mural Repository of Shaanxi History Museum [C]// Chinese Chemical Society Applied Chemistry Discipline Committee. Documentation of Cultural Relics Protection and Restoration —— Proceedings of the 8th National Conference on Archaeology and Cultural Relics Protection (Chemistry). Shaanxi History Museum; College of Cultural Heritage and Museology, Northwest University; 2004:13.

[9] GB/T 15265-1994, Determination of Dust in Ambient Air by Weight Method [S].

[10] Zhang Ting. Study on the relationship between surface dust and salt efflorescence in sculpture ground[D]; Chang an University, 2021.

[11] HJ 802-2021 Determination of dust in ambient air by gravimetric method [S]. Beijing: Ministry of Ecology and Environment, 2021.

[12] He Zengxin. Study on the mechanism of interaction between water and salt and dust accumulation on statue surface for the treatment of alkali-saline disease[D]. Chang an University, 2022.

[13] Sun Donghuai, Su Ruixia, Chen Fahu, et al. Composition, flux and magnetization rate of modern natural dust deposition on the Loess Plateau [J]. Acta Geographica Sinica, 2001(2):171-180.

[14] Qian Xiangyu, Wang Qiqi, Wang Dantong, et al. Enrichment characteristics of heavy metals in corn leaves from dust with different grain sizes [J/OL]. Journal of Agricultural Environmental Science, 1-17[2025-01-20].

[15] Xu Jie, Luo Deping. Research and Application of Dust Automatic Monitoring System in Shanghai [J]. China Environmental Monitoring, 2024, 40(2):205-211.