

MOULD PREVENTION STRATEGIES FOR LIBRARY BUILDINGS IN TROPICAL CLIMATE

Suriani Ngah Abdul Wahab¹ and Md Yusof Hamid²

*Building Surveying Division, Faculty of Architecture, Planning and Surveying,
Universiti Teknologi MARA Seri Iskandar Campus, Seri Iskandar, 32610, Perak,
Malaysia*

suria275@perak.uitm.edu.my

Received: 11 April 2018

Accepted: 21 June 2018

Published: 30 September 2018

ABSTRACT

This paper presents mould prevention strategies that should be applied in the library buildings. Library constructed in tropical climatic conditions must be moisture controlled from fungi or mould growth on any potential material. In order to identify the magnitude and the causes for mould growth, comprehensive research was carried out within three libraries in Malaysia universities. Aspergillus, Penicillium, Stachybotrys's and fungal had been identified as a common mould growth found. Thus, the growth of mould on the building elements such as walls and floors carpets, books, air conditioning parts of the surrounding library areas will be inevitable unless prevention strategies applied. Four strategies have been identified as possible mould prevention strategies in the library building.

© 2018MySE, FSPU, UiTM Perak, All rights reserved

Keywords: indoor environment; moisture; mould growth; library

1.0 INTRODUCTION

Mould created on various building elements and materials produced spores which are harmful to the end users in the library. Therefore it is important to eliminate the mould and fungi in an indoor library environment. Thus, from the health point of observation, the presence of mould on books could create a possible source of health risks to those working in the libraries and the users, especially those that are used to putting their hands in the mouth before flipping through the pages of books (Bankole, 2010). In addition, the remediation and action should be carried out immediately when the sign of mould appear in the building. Failure to do this, it will cause the risk of exposure of mould spores in the building. The five critical environmental factors for the growth and development of moulds in library collections will be determined by the presence of mould spores, the source of nutrients, adequate moisture, the conducive temperature for a particular mould, and limited air circulation (Adan Olaf CG & Robert, 2011; Isaksson, Thelandersson, Ekstrand-Tobin, & Johansson, 2010; Rahman, Rasul, & Khan, 2008)

The most important factor in the preservation of library collections is the maintenance of proper environmental conditions. The various design including operations and maintenance problems have been identified as the causal factors to the infestation of mould in the building (Maisarah Ali, 2010). Therefore, the prevention strategies including design and maintenance of the library buildings are needed. This paper presents part of PhD research and focusing on the prevention strategies to overcome the mould growth in an indoor library environment.

2.0 LITERATURE REVIEW

The library design and layout play important roles in minimizing mould growth and its effect on the users. Preservation Advisory Centre, United Kingdom (2012) had produced a guideline for mould outbreak in the library and archive collections (Emma, 2012). These guidelines are useful for librarians in terms of providing mould information and its lifecycle,

requirement of good indoor environment and material storage guidelines (Child, 2011). These including several precautions and guides for preventing moulds in the indoor libraries such as materials place, storage, protection from water, dirt and dust and regular inspection material on lower shelves. The American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE, 2012) also developed a classification for the preservation of books in the indoor climate that can be applied in the indoor library environment. In practice, fumigation has become the regular cure for books assumed to control insects or fungi or books in which an insect or fungus had been observed (Jan, 2006) but not recommended because of human health concerns (Weaver-meyers, Stolt, & Kowaleski, 1998). Preventing and treating mould infestation in the library building should preserve human health first and its collections.

Therefore, several guidelines and strategies had been developed from literature and guidelines from relevant authorities and also from the result of the case studies to ensure indoor library environment free from mould growth from assessment as shown in Figure 1 below.

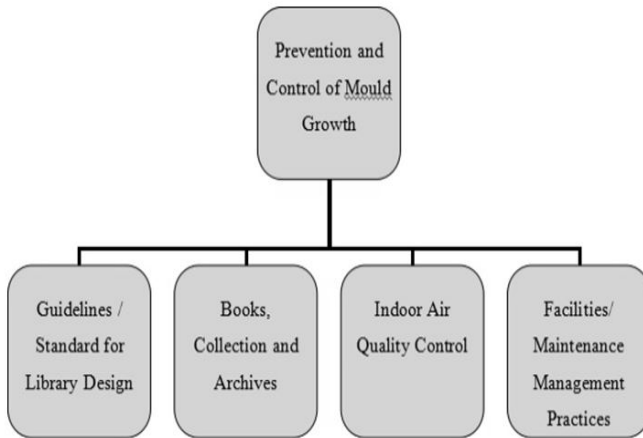


Figure 1: Prevention and control of mould growth in Library building Guidelines for Mould Prevention and Control

There are several guidelines developed and published for the protection of public health from health risks due to dampness, associated microbial growth and contamination of indoor spaces. The guidelines are based on a

comprehensive review and evaluation of the accumulated scientific evidence by a group of experts. The International Federation of Library Associations (IFLA) had developed principles of care and handling of library material in 1998. These principles consist of the preservation and conservation of library material including the aspect of library environment with a section on handling mould growth. In 2008, American Industrial Hygiene Association (AIHA) published a book titled 'Recognition, Evaluation and Control Indoor Mold' in which produce comprehensive guidance for industrial hygienists on the topic of mould assessment (Prezant, Weekers, & Miller, 2008).

In addition, The World Health Organization (WHO) in 2009, had developed and published guidelines for indoor air quality focusing on dampness and mould in the indoor environment (WHO, 2009). The guidelines cover the aspect of mould growth and its relation to health effects associated with dampness, assessment methods, moisture control and ventilation and evaluation of human health risks and guidelines.

Preserve Books, Collations and Archives

The use of chemical fungicides and fumigants, while often temporarily successful, is not normally acceptable as they have limited efficiency, may be toxic, and have the potential for damaging collection items. The use of chemical fungicides and fumigants does not address the underlying problem of poor environmental control or building defects (Child, 2011). Long-term prevention of mould and control of outbreaks is only possible by the effective environmental control to ensure that conditions are unsuitable for growth.

Ventilation System Control

The ventilation system control by using comprehensive utilization of the following ways can achieve effective control of mould contamination. The specific criteria for ventilation systems that required in reducing the risk of mould growth as stated in WHO (2009) guidelines are as follow:

- a) Ventilation air should be distributed and used effectively in the building
- b) Air used for ventilation should be clean

- c) Ventilation should be provided to a building in an energy-efficient way
- d) Ventilation should be controllable by the occupants
- e) Quality control in design and construction
- f) Maintenance of ventilation systems

Preventive Maintenance

Preventive maintenance that involves fixing things at the earliest sign of deterioration has a better chance of minimizing the potential for major moisture and mould disasters (Small, 2009). An air-conditioning system that does not receive proper maintenance can be more harmful to book collections (Reis-Menezes, Gambale, Giudice, & Shirakawa, 2011). Therefore, planned maintenance and properly funded preventive maintenance program are essential to prevent and control mould growth in the library building. The inspection should always include identification of the source of moisture or water ingress into the building.

3.0 METHODOLOGY

This research adopted a qualitative-dominant design with the inductive procedure. The data gathered in the natural and real situation of three selected case studies. The sites were surveyed with the following criteria:

- (a) The collection of library building characterization data based on direct inspection and interviews with library officers;
- (b) The library characterization including measurement of temperature and humidity, lighting and air conditioning systems;
- (c) Physical examination of the building and inspection of sites that has been wetted or showed mould growth; and
- (d) Mould sampling and analysis as shown in Table 1 and Figure 2.

Table 1: The Summarised of Sampling Perform in Library Buildings

Method	IRC	PTAR1	PSZ	Purposed
Coriolis Air Sampler	√	√	√	Mould Identification
Settling Plates Air Sampling	√	√	√	Mould Identification
Swab Test (IAQ Mold)	√	√	√	Mould Identification
Swab Test	√	√	√	Mould Identification
Carpet Sampling	x	√	x	Mould Identification

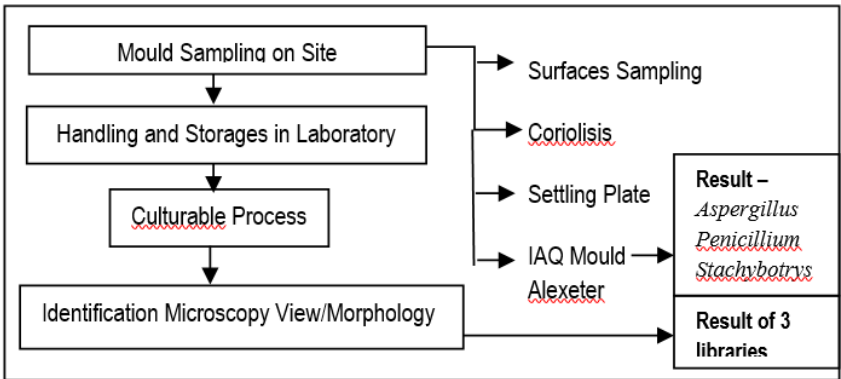


Figure 2: Mould Identification and Quantification Process

In this research, semi-structured interviews and open-ended interviews have been adopted. An interview schedule was set up, and questions were designed before the interviews were conducted. The interviews were conducted with two different personnel of University management: the chief librarian and the maintenance personnel that involved in maintaining the library building. During the three case studies investigation, interviews with the librarian of selected libraries were conducted. The question-answer session was held formally before the researcher did the measurements. The questions started with general matters, then moved to a particular issue

regarding mould growth.

The question aims to get feedback about the libraries environments, problems and experience. The information from them may help the researcher to know the scenario happen to the libraries about the condition of building physical and mechanical and ventilation condition.

The questions are focusing on ventilation system review, HVAC system in libraries and maintenance aspects. The researcher gathers data and confirmation of possible causes of mould growth. In addition, information on the water or moisture symptoms from past and current leaks, spills and condensation; review ventilation and note apparent mould, and area with mouldy and musty odours been reviewed during the session.

4.0 RESULTS AND DISCUSSIONS

The three libraries experienced with mould growth especially on the books, air conditions outlet and ceiling. The type of mould found are *Aspergillus* sp., *Penicillium* sp. and *Stachybotrys* sp. However, only *Rhizoctonia Solani* sp. found in library B due to the existence of soil inside the building. The prevention strategies that can apply to the three case studies are as follows:

Adopting Guidelines for Mould Prevention and Control

There are several guidelines and procedures should be adopted by the library management for mould prevention and control such as:

- i. International Federation of Library Associations (IFLA) - principles of care and handling of library material.
- ii. American Industrial Hygiene Association (AIHA) - Recognition, Evaluation and Control Indoor Mold.
- iii. World Health Organization (WHO) – Dampness and Mould: Guidelines for Indoor Air Quality.
- iv. Occupational Safety and Health Administration (OSHA).
- v. Ministry of Health Malaysia - Guidelines on Mould Control and Remediation in Healthcare Facilities.
- vi. Public Work Department, Malaysia - Guidelines on the Prevention of

Mould Growth in Buildings.

From the case studies, it revealed some the guidelines and procedures not been followed by the library management. This situation beyond control such as operation and maintenance work is operated by the other department. Therefore, backlog maintenance due to certain reasons and mould growth in the library. Another example, the temperature and relative humidity of the libraries as stated in the guidelines by International Federation of Library Associations (IFLA) recommended 18°C to 20°C air temperature and 50% to 60% relative humidity (RH) in the indoor library environment. However, the result of the three case studies as shown in Table 1 below indicated that these guidelines not been followed and a higher risk of mould growth

Table 1: Average Data of Temperature, Relative humidity and Lux for Three Libraries

Case Study	LIBRARY A				LIBRARY B		LIBRARY C			
	G/Floor	L1	L2	L3	L3	L4	L2	L3	L4	L5
1 [°C]	21.07	22.53	23.50	23.17	23.89	26.28	20.36	21.18	21.50	24.71
2 [%RH]	71.71	67.56	67.60	69.22	68.89	64.56	74.63	70.19	69.85	74.41
3 [Lux]	13.26	4.16	2.59	21.98	0.84	1.65	0.24	3.73	1.01	3.32

Elimination Sources of Moisture

It is vital for any library no matter what its size to avoid from any source of moisture. Whether they be natural or man-made. Many of guideline had stress on this matter. It is clear mention that the entrance of water or any incursion into buildings that are damaged, poorly designed, or improperly maintained, is the main source of mould growth and its associated building-related illness (Occupational Safety and Health Administration, 2006). The thing needs to take into account are to identify and eliminate sources of dampness, high humidity, and moisture to prevent mould growth.

The analysis result data for Library A, B and C show all libraries experienced with mould growth especially on the books, air conditions

diffusers, ceiling and carpet. One of the main causes of the existence of water that contribute to mould growth within the library buildings. The results of both libraries such as Library B and C show the similar problem of severe moisture penetrate into the building. They had experienced on roof system failure, therefore, the upper floor presence mould at many places especially on the ceiling and a few places on the wall and floor. The most interesting finding was the collapse of the ceiling at level 5 of Library C and the water rindrop at those level during visual inspection as shown in Figure 1.



Figure 1: Leaking Roof Cause Ceiling Damage, Moisture and Mould Growth at Level 5 of Library C

Library B had an experience of the failure of rainwater downpipe and flat roof system. The improper maintenance work such as clear out the dry leaves and debris slow the rainwater get through the pipe. The dry leaves and debris in the area of flat roof gutter is not been cleared and start to block the drain especially during heavy rain. These should be cleared out during a regular maintenance schedule. Therefore the water intrusion from the rainwater downpipe (RWDP) in the timber column contributed moisture inside this library as shown in Figure 3 below.



Figure 3: Roof and RWDP Failure Cause Timber Column Damage, Moisture and Mould Growth at Library

The symptoms such as wet or damp spots, non-mouldy materials should be cleaned and dried as soon as possible. As mention in Occupational Safety and Health Administration (OSHA), preferably within 24 to 48 hours of discovery of the symptom. Prevention of moisture due to condensation also found in the libraries. To prevent this situation the management of the library need to increase the surface temperature of the material where condensation is occurring or by reducing the moisture level in the air.

In addition, the library building should be checked routinely for water leaks, problem seals around doors and windows, and visible mould in moist or damp parts of the building. All conditions that could be causes of mould growth should be corrected to prevent future mould problems.

Planned Preventive Maintenance

One of the main causes of mould growth within library buildings is poor maintenance. As mention before the potential growth of mould is moisture and the key to mould prevention is moisture control. Therefore the important initial step in prevention is a visual inspection of the libraries and the execution of maintenance work as planned. Regular inspection of the building envelope and drainage systems should be made to guarantee that the system is in working order. From the case studies, it found that corrective maintenance is not been carried out at Library B and C building. The work included reducing the moisture level in the air, repairs leak, cleaning and service air conditioning outlet.

The guidelines on the prevention of mould growth in buildings by Public Work Department highlighted the importance of operation and maintenance stage. The maintenance work should be planned and carried out by a competent person and the execution of maintenance work should be planned earlier and works carried out at a predetermined time. The ventilation and air conditioning system should be monitored and measurement of its performance to ensure the ventilation and temperature in indoor library adequate and not causes the mould growth. Microbial growth on wet surfaces in air handling systems is a major source of pollution in old library buildings such as library B and C. Moisture-related on ventilation and air conditioning components such as cooling coils and humidification systems when poorly maintained, can be a source of mould growth and

microbial contaminants that effect in library users.

The importance of cleaning of this systems as stated in many guidelines and standard should be followed by the library management. Therefore, all ventilation systems in the three case studies require regular inspection and maintenance.

Preserve Books, Collations and Archives

From the visual inspection of the three case studies, it found that some of the books on the book rack especially at crawls area are identifying with mould symptom on the book cover such fuzzy spot or powdery. This condition due to the area of crawling spaces got less of light, exposed to dust and humid. The relative humidity condition at 61% to 80% was one of the factors that contributed to the humid in the ambient and therefore mould growth at a certain area in this three libraries. It also due to the books immobile or recess at the same place and didn't get decent airflow. The mould growth on the books cover is shown in figure 4 below.



Figure 4: Mould Growth on the Binder Books in the Libraries

In addition, it was found that some of the books on the book rack located on the ground floor are identifying with dust on the book cover. The books were also swelling and shrinking. The relative humidity condition at 61% to 76% was one of the factors that contributed to the humid in the

ambient and therefore mould growth in a certain area at library A, B and C. The moisture exists on the books surfaces due to the condition of relative humidity more than 60% of the recorded data.

It is interesting to note that in all three cases of this study found the mould like to grow on the dark colour binder book. The binder books or cloth book made from organic material. As mention in a previous research paper, the nutrient of the mould is the thing that made from organic due to the mould does not have any chlorophyll and, therefore, cannot produce their own food. However, any building material can turn as a substrate for mould to grow on, as well as concrete masonry as long as dust and debris exist. The mould still needs moisture and warmth to grow but they prefer darkness. The study found that almost all darken the colour of binder book has the presence of mould. Another important finding was that there is no symptom of mould growth found on the bookbinder cover has a bright colour such as orange. Therefore, it is important for the library management to ensure the books and archives been preserved as the required guidelines.

5.0 CONCLUSION

This paper justified the importance of prevention and mould control in the library building. Data analysis and findings that have been discussed shows that there are requirements and guidelines not be followed by the library management to reduce the mould growth in the existing libraries. The elimination of moisture in the library building is an integral part of reducing and preventing mould growth. Therefore, planned preventive maintenance should be carried out for the physical aspect of the library building including regular maintenance of the ventilation and air-conditioning system. The method of preserving books, collations and archives in the library should follow the guidelines and procedure recommended by the various agencies and library authorities. Failing to apply this requirement result to the risk of books and archives damage and possibilities of uncontrolled mould growth in the indoor library environment.

ACKNOWLEDGEMENT

The author gratefully acknowledges the Universiti Teknologi MARA, Seri Iskandar Campus, Seri Iskandar and Ministry of Education Malaysia for supporting this research study.

REFERENCES

- Adan Olaf CG, & Robert, S. A. (2011). Introduction Of Fundamentals of Mold Growth in Indoor Environments and Strategies for Healthy Living. In *Fundamentals of Mold growth in Indoor Environments and Strategies for Healthy Living* (p. 302). Netherlands: Wageningen Academic Publishers.
- Bankole, O. M. (2010). A review of biological deterioration of library materials and possible control strategies in the tropics. *Library Review*, 59(6), 414–429. <http://doi.org/10.1108/00242531011053931>
- Child, R. E. (2011). Mould Outbreaks in Library and Archive Collections. *British Library (Preservation Advisory Centre)*, (2004), 7.
- Emma, D. (2012). *The Preservation Advisory Centre*.
- Isaksson, T., Thelandersson, S., Ekstrand-Tobin, A., & Johansson, P. (2010). Critical conditions for onset of mould growth under varying climate conditions. *Building and Environment*, 45(7), 1712–1721. <http://doi.org/10.1016/j.buildenv.2010.01.023>
- Maisarah Ali. (2010). PAPER 25. In *Assessment of Moulds Growth In Selected Hospitals : Air – Conditioning Systems Aspects*.
- Occupational Safety and Health Administration. (2006). *Preventing Mold-Related Problems in the. Safety And Health*.

- Prezant, B., Weekers, D. M., & Miller, J. D. (2008). Recognition, evaluation, and control of indoor mold. American Industrial Hygiene Association.
- Rahman, M. M., Rasul, M. G., & Khan, M. M. K. (2008). Sustainability in Building Environment : A Review and Analysis on Mould Growth in a Subtropical Climate, 3(3), 287–295.
- Reis-Menezes, A. A., Gambale, W., Giudice, M. C., & Shirakawa, M. A. (2011). Accelerated testing of mold growth on traditional and recycled book paper. *International Biodeterioration & Biodegradation*, 65(3), 423–428. <http://doi.org/10.1016/j.ibiod.2011.01.006>
- Small, B. M. (2009). Creating healthier buildings. *Toxicology and Industrial Health*, 25(9–10), 731–5. <http://doi.org/10.1177/0748233709348284>
- Weaver-Meyers, P. L., Stolt, A., & Kowaleski, B. (1998). Controlling Mold on Library Materials with Chlorine Dioxide: An Eight-Year Case Study, (November), 455–458.
- WHO. (2009). WHO Guidelines for Indoor Air Quality (Dampness and Mould). (E. Heseltine & Jerome Rosen, Eds.). Copenhagen: World Health Organization Regional Office.
- WHO. (2009). WHO Guidelines for Indoor Air Quality (Dampness and Mould). (E. Heseltine & Jerome Rosen, Eds.). Copenhagen: World Health Organization Regional Office.