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Indoor Air Quality of Historic Buildings: A Comparison of Certified to Non-certified Buildings

Jacqueline Furcha Stephens[1], Farah Abaza[2]

[1]Construction Management, Kennesaw State University, Marietta, United States
[2]Biology Major, Kennesaw State University, Marietta, United States

Email address:
jstep109@kennesaw.edu (J. F. Stephens), abaza.h.farah@gmail.com (F. Abaza)

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Abstract: Since, there is a high level of concern for historic buildings becoming sustainable this paper will investigate the indoor air quality of three historical buildings that are on the National Registry of Historic Buildings and located around Fulton County, Georgia, USA and three historical buildings that are not certified in the same area. The certification for the three certified buildings was obtained thru Earth Craft Sustainable Preservation program, which is the only historic building certification in the United States. The research entails field measurements of CO_2 levels, air borne particles (both types and sizes), and greenhouse gas emissions. This was done by counting the airborne particles with sizes between 0.3 to 5.0 nanometers, and identifying biological and non-biological airborne particles both indoors and outdoors. These tests were used to determine if the interior of the certified buildings have better CO_2 levels than the exterior and to ascertain how much the certification process effects the indoor air quality. This information will be compared to the noncertified buildings to ascertain if the results of the testing will show that the indoor air quality and greenhouse gases are better than the noncertified buildings. This research will demonstrate the need for improved indoor air quality testing in historic buildings before certifying them as being sustainable in the area of indoor air quality.

Keywords: Indoor Air Quality, Historic Buildings, Particulate Matter, CO_2

1. Introduction

Past ASHRAE President, Gordon Holness explained that bringing historic buildings up to sustainable standards by allowing them to be certified as sustainable is the most beneficial process for the environment [12]. These buildings are important to society because they help maintain the roots of the community, while keeping the city more attractive [1]. They have an important role in conserving our cultural and architectural heritage [10]. Historic buildings have an intrinsic value; they teach children how the world has changed and grown over the years [11]. Jane Jacobs wrote in her book, "*The Death and Life of Great American Cities*," that "new ideas must use old buildings," without the old buildings to learn from new ideas will become stagnant [8]. Preservation of historic buildings is important because it contributes to the city's idea of itself, it helps maintain the roots of a community while keeping the city attractive [1]. It is a tangible symbol in the community's desire to honor their heritage and sense of place by renewing an anchor of the community [7]. Jacobs also stated that if a city loses its history the character of the community declines because the citizens have lost the heart of their neighborhood.

The idea of sustaining historic buildings is becoming so necessary that the Georgia Trust and South face developed a certification, Earth Craft Sustainable Preservation program (ECSP) [15]. This standard is designed to make the buildings more sustainable without ruining their authenticity while maintaining the look and design of the historical structure as it looked in its past state [14]. This is the only certification program in the United States and it has been designed to only cover the southeastern United States. The program promotes clean energy, water efficiency, and sustainability in homes and historic buildings through prerequisites and credits that need to be obtained in order to receive certification [14]. They are

1. Sustainable Sites/Site Planning & Development
2. Water Efficiency

3. High Performance Building Envelope
4. Construction Waste Management
5. Resource Efficiency
6. Indoor Air Quality
7. Durability & Moisture Management
8. Energy Efficient Building Systems
9. Innovation
10. Education & Operation

This paper will focus on indoor air quality by using three historic buildings certified by ECSP as sustainable; they will be compared to three noncertified buildings; all located in Fulton County, Georgia, United States. There are several definitions for indoor air quality (IAQ) but the two from prominent associations like Environmental Protection Agency (EPA) and Association of Heating, Refrigeration, and Air-Conditioning Engineers (ASHRAE) are more accurate. The EPA refers to IAQ as the "air quality within and around buildings and structures, especially as it relates to the health and comfort of building occupants" [5]. ASHRAE on the other hand, states in Standard 62, 2007 that acceptable indoor air quality is defined as the air inside a building should not contain contaminants that are at harmful concentrations and where 80% or more occupants do not express discontent. The standard is concerned with the requirements needed based on the chemical, physical, and biological contaminants. The article *Defining Indoor Air Quality (IAQ)* in CMS Mechanical stated that the ASHRAE definition was more specific and a better definition.

Historic buildings have a larger problem with IAQ due to the high potential for mold which forms in to microscopic spores and gases causing the musty smell that has the potential to cause symptoms from allergic reactions to asthma and even cancer [9]. Much of this mold comes from the prevalent amount of moisture that manifests through mold germination within older buildings; this moisture which can erode, rot, corrode, and deteriorate aging building materials and artifacts [10, 6]. The level of particulate matter in the air can also affect people, artifacts and the buildings. Artifacts in the buildings are more susceptible to chemicals, particulate matter, temperatures, and relative humidity because they are comprised of natural organic materials [3]. The highest threat to the preservation of these items is atmospheric pollution [4]. Pollution concerns include the level of particles that reach every surface from walls and floors to historic artifacts creating a loss in value and visibility to visitors [2].

Chemicals in the air effecting the people and artifacts are ones such as carbon monoxide (CO), carbon dioxide (CO_2), nitrous oxide (NO_3), formaldehyde (HCHO or CH_2O), ozone (O_3), and other Volatile Organic Compounds (VOCs) [13]. In order to protect employees and visitors, to preserve artifacts for future generations, and to guard against the destruction of the authenticity of the building itself it is important to reduce the chemicals in the air of historical buildings.

For this research six buildings were chosen to have air quality analysis done, all of them are located around Fulton County, Georgia, USA, three historical buildings which are on the National Registry of Historic Buildings and certified sustainable and three historic buildings that have not been certified at this time. The definition used for determining a historic building is one that is at least fifty years old, looks almost like it did in the past, must have an association with past people or events, and significant architectural history. The range of dates for the certified buildings is 1870-1905 and the uncertified buildings 1832-1839. For the certified buildings Building A was built in 1895 and the renovations were done in 2015, Building B was built in 1905 and the renovations were 2014, and Building C was built in 1870 with the renovations completed in 2015. For the uncertified buildings: Building 1 was built in 1832, Building 2 1839, and Building 3 1850.

Changes in the certified buildings include the following (Table 1).

Table 1. *Changes Made in the Certified Buildings.*

	Building A	**Building B**	**Building C**
Switch lighting to LED	X	X	X
Water efficient plumbing fixtures	X	X	
Energy Star HVAC units with web-based wireless thermostats	X		
Energy Star water heaters	X		
Energy Star appliances	X		
Insulate attic	X		X
Vapor Barrier in attic	X		
Interior storm windows	X	X	X
Weather stripping in doors	X		
Seal & insulate crawl space		X	X
Switch gas equipment to electric		X	
Point-of-use water heaters at faucets		X	X
Air seal & insulate attic		X	
Insulate HVAC refrigerant lines		X	
Programable thermostats		X	
Insulate hot water pipes		X	
Insulate exterior walls			X
Replace HVAC system			X

2. Methodology

Three tests were run in various spaces within the six buildings the tests are being used to determine the difference in levels between the interior and exterior of the buildings and to compare the levels between the certified and the uncertified buildings. The MetOne Particle counter was used to detect the number of particles in the air in sizes from 0.3 to 5.0 nanometers. To collect airborne particle samples, Air-O-Cell air sampling cassettes were used to collect air samples. It collects the airborne aerosols on the glass slide inside of the cassette while releasing the filtered air through the other end. These cells are designed to collect a wide range of airborne aerosols such as mold spores, pollen, insect parts, skin cells, fibers, and inorganic particulates [16]. The collected particles were taken to the laboratory and placed on microscope slides to analyze what type of particles were in the air. Using a picture microscope, and stain for those slides that required, we were able to take pictures of the airborne particles which were then used to analyze the types of air particles found in both certified and uncertified buildings. Lastly, CO_2 levels, relative humidity, and temperature were checked by using the Supco IAQ55 indoor air quality monitor. All tests were run in the interior and exterior of the buildings.

3. Results

The results of CO_2 levels, relative humidity, temperature, and particle amounts at the various nanometers for the certified buildings can be seen in Figures 1-3 and the uncertified in Figures 4-6.

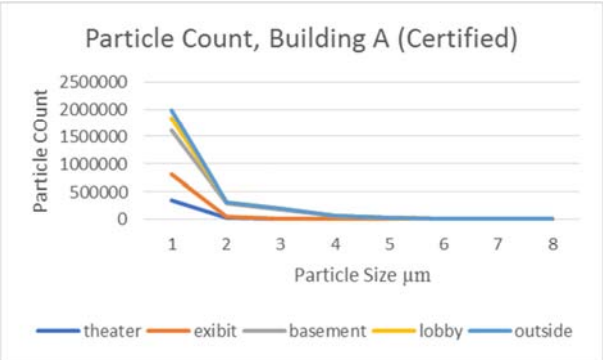

Figure 1. *Building A Particle Counts.*

The findings showed no significant difference in the indoor air quality of buildings both certified and uncertified. The biological samples had minimal biological agents. There was also minimal variation in the airborne agents that were found indoors between those buildings that had been renovated and those that had not. Among the particles found we discovered penicillum (shown in Figures 7 & 8), a fungus that has many strains but which is believed to be non-harmful in a museum and event hall environment. Overwhelmingly, what was found in both the certified and uncertified buildings was various forms of dust and dust mites which could be defined as allergens.

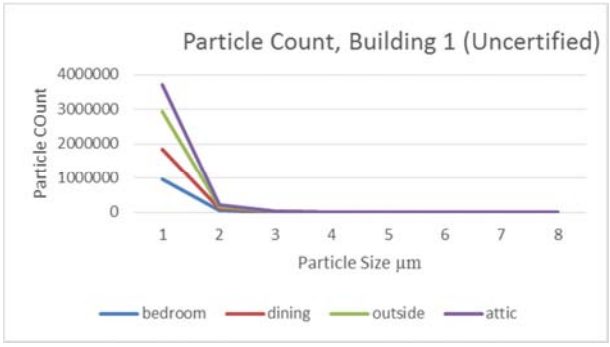

Figure 2. *Building B Particle Counts.*

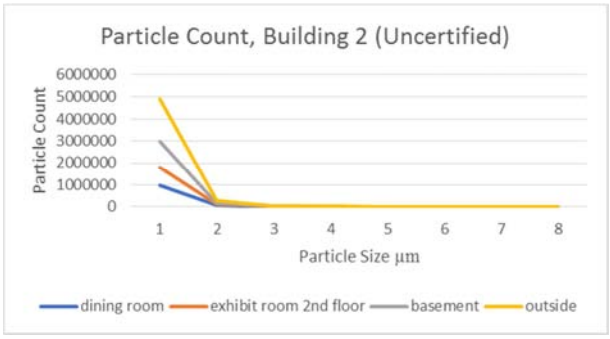

Figure 3. *Building C Particle Counts.*

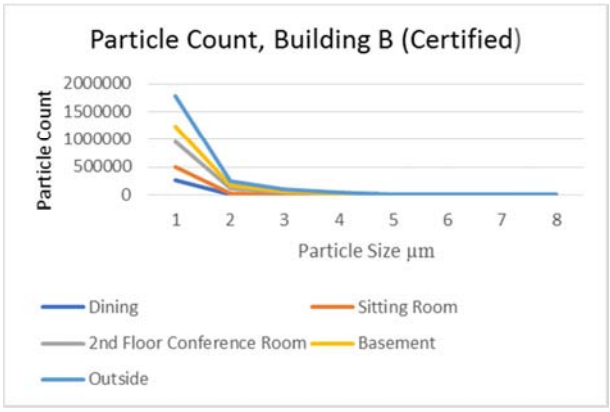

Figure 4. *Building 1 Particle Counts.*

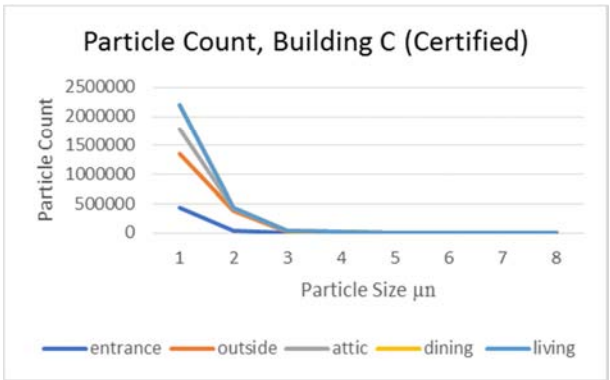

Figure 5. *Building 2 Particle Counts.*

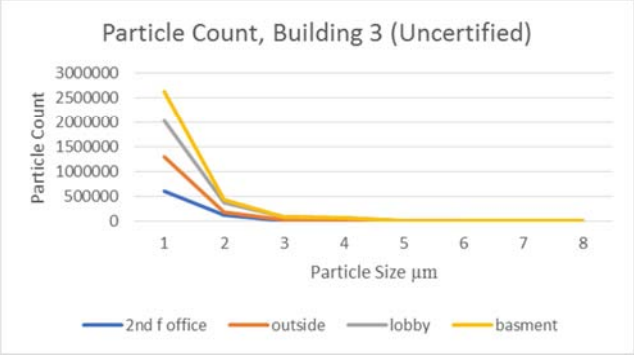

Figure 6. *Building 3 Particle Counts.*

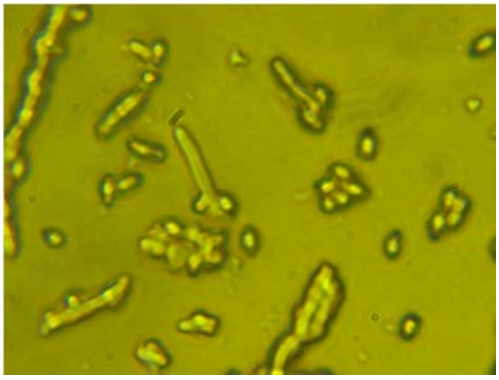

Figure 7. *Possible Penicillum fungus sample gathered from a certified site.*

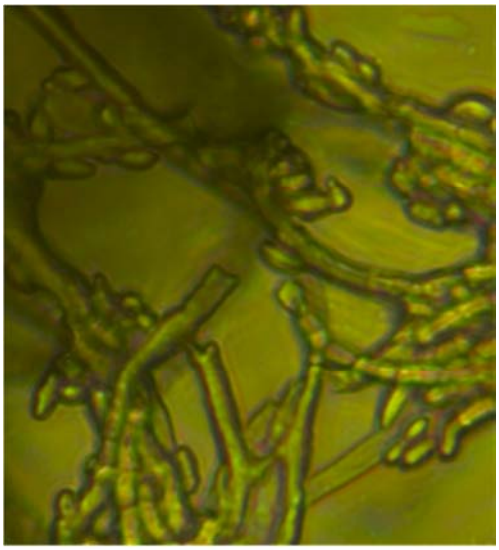

Figure 8. *Possible Penicillum fungus sample gathered from an uncertified site.*

4. Conclusions

After running the analyses, it was determined that there were no significant differences between the indoor air quality and airborne agents of the certified buildings (renovated) and the uncertified. The highest level of particulates were various forms of dust and dust mites which could affect allergies. The exterior particle count was 43% higher than the inside count. This is what should have been seen because the interior environment would be cleaning the entering air.

5. Recommendations

The buildings need to pay special attention to reducing infiltration rates and improving the HVAC systems to include filtered and controlled outdoor intake. After reviewing the results, it was found that the air particle count was much higher in the basements or crawl spaces unless they had insulation and water proofing. It is important to prevent air leakage in the basements. More testing should be done to determine the variances in different weather conditions. The HVAC systems should be included in future research.

Jacqueline F. Stephens taught construction management at Westwood College until 2016 when she became an Assistant Professor at Kennesaw State University in Marietta, Georgia. She is currently working on her Ph. D. in Technology Management specializing in Construction Management. Her interests are in historical building preservation and sustainability.

Farah Abaza is a junior at Kennesaw State University majoring in Biology with a focus in pre-medical sciences. Her coursework included microbiology and cell biology. She is currently conducting research with the Ophthalmology department at Grady Memorial Hospital. Farah maintained a 4.0 GPA at Kennesaw State University.

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