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Review Article

Museums and Monuments in Nigeria: Reducing Pollution Damage

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Abstract

The importance of museums and monuments in Nigeria and elsewhere in the world is not far-fetched. They provide a rich evidence and concise information regarding old civilizations and cultures of different peoples. The safeguarding of monuments is one of the most urgent priorities, involved in the good preservation and conservation methods of all monuments and museums that have important artistic and historic values. The Museum houses monuments, which are either stored or exhibited. Artifacts in the museums need a good environment, which includes an atmosphere free of dust and pollutants. The air (outdoor and indoor) unfortunately, is often polluted. The pollutants are either from anthropogenic or non-anthropogenic source. Deterioration of museums and monuments by the pollutants is usually slow and progressive, a prolonged exposure can cause severe or minor damage to a wide range of items. If problems due to pollution are identified, what needed to be done is to test for the pollutants and to measure their quantity. To do this, samples of the area would be collected, analyzed and the results will be compared with published standards and damage threshold levels. In this paper, an overview of the types of museums, pollutants, damage and deterioration that are caused to people, materials and monuments, instruments for monitoring and steps to reduce the pollution effects was discussed. It is hoped that this paper will inform or assist Nigerian museum personnel in tackling pollution problems likely to destroy the cultural heritage of the nation.

Keywords, Museums, monuments, Artifacts, pollutants, NO_2, indoor, outdoor, Assessments, Nigeria.

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Introduction

It is a fact that Nigerians inhale daily a deadly mixture of Particulate Matter (PM), asbestos, Sulphur Dioxide (SO_2), Nitrogen Oxide (NO), Carbon Monoxide (CO), and partially unburnt hydrocarbons (Uwaegbulam *et al*., 2015). Globally, these substances contribute to the death of seven million people – one in eight of total global deaths, released by WHO recently. Air pollution is the world's largest single environmental risk (WHO, 2014). According to Uwaegbulam *et al*. (2015), there is a link between indoor and outdoor air pollution exposure and cardiovascular diseases (strokes, cancer, and ischemic heart disease). Also, air pollution has a role in the development of respiratory diseases (with acute respiratory infections and chronic obstructive pulmonary diseases).

The effects on the potential damage to historical monuments have already been realized. This damage may be as a result of wind or rain. The effects may be small or may have permanent consequences (Rogers, 2017). Acid rain occurs when fossil fuel emissions containing sulphur dioxide combine with moisture in the air to form acidic precipitation. Global warming (Temperature increase) is another factor that affects historical monuments. Global warming occurs when greenhouse gases such as CO_2 trap radiant heat at the earth's surface, which causes temperatures to rise. Other factors are humidity which gives the necessary environment for corrosive chemical reactions. Sun radiation can increase temperatures on the surface of the artifact, show the effects of global warming on a specific area (Rogers, 2017).

In New Delhi, there is an evidence of the happening to the Taj Mahal in Agra. The limestone is the gradual yellowing of the walls (PTI, 2016). In Acropolis, Greece, it is recorded that air pollution has negative impacts on historical monuments and buildings. The Baha'i worship center in Kalkaji has been slowly turning grey (Biswas, 2015). In San Francisco de Campeche City, Mexico, Reyes *et al*., (2011), recorded the degradation of the historic building. Kanani and Zandi (2011), depicted the effects of acid rain on Alavian dome and the Jewish Synagogue, Hamadan, Iran.

Nigeria is blessed with resources (natural and human). Today, over 500 tribes are on the shores of the nation. Apart from these, Nigeria is historically and culturally rich with monuments which are found across the country. Maintenance is one of the greatest problems faced by the museum authorities. Adedeji and Opeyokun (2010) from their study, revealed that part of the monumental building (35% partial collapse) in the South-west of Nigeria is affected by the environmental pollution and parts affected are solid blocks.

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In this review article, museums, damages to historical monuments, pollutants and air pollution are discussed and suitable remediation is provided.

What are Museums and Monuments?

Museums house cultural heritages which are kept in safe custody of the curators and other members of staff. A museum is supposed to be a non-profit institution which is open to the public, it also acquires, conserves, researches, communicates and exhibits the cultural heritage for the purposes of education, study and enjoyment (Walhimer, 2017). Walhimer (2017), names the types of museums as follows: Zoos, History museums, Historic sites, Historic houses, Sculpture gardens, Transportation museums, Nature centers, Military museums, Arts center, Art museums, Aquarium, Natural history museums, Science/Technology centers, Botanic gardens, Anthropology museums, Children's museums, Local & State History museums, Visitor centers.

Museums and monuments in Nigeria

Monuments in Nigeria

Many monuments have been identified in Nigeria. Each state of the federation is housing different cultural heritages and other tourist attractions. In 2013, the Director of National Commission for Museums and Monuments listed new one hundred (100) monuments across the country to mark Nigeria's Centenary celebration (Daniel, 2013). Over one thousand different heritages have been identified in different states of Nigeria. Work is ongoing for the discovery of others. To take care and preserve these monuments, Federal and States governments have saddled the National Commission for Museums and Monuments (NCMM) to oversee this task.

The NCMM was established in 1979 by Decree No 77 of 1979 to oversee the museums and monuments in Nigeria. The objective of the commission was to discover, collect, preserve and research into the traditional cultures of the various peoples of Nigeria and making the results of such studies known to them.

Vision

A Stable Museum System, which ensures the preservation and integration of the Nigerian Cultural and Natural Heritage within the Local and National developmental process and the World Heritage Network.

Mission

To systematically collect, preserve, study and interpret the material evidence (tangible and intangible) of the people of Nigeria and Nigerians in the Diaspora.

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Between 1968 to date, NCMM had a Sole Administrator, two acting DGs, and seven substantive DGs/Chief Executives. Expansions of museum and monuments have spread to almost all the states in Nigeria.

Pollution

Types of Pollutants

According to Blades *et al*. (2000), Museums, archives, libraries, and galleries are vulnerable to risk due to exposures to the gaseous and particulate pollutants. Depreciation is usually slow, continuous and progressive. Extensive exposure to the pollutants can cause severe damage to a wide range of items. For the purpose of this review, airborne pollution within the museum environment comes from both the indoor and outdoor sources. Air pollution in and around the museums is either anthropogenic or non-anthropogenic in nature.

Examples of gaseous pollutants are Sulphur dioxide (SO_2), Nitrogen dioxide (NO_2), Ozone (O_3), Hydrogen sulphide (H_2S), Formic acid (HCOOH), Carbonyl sulphide (OCS) and Formaldehyde (HCHO) (Table 1). The dissolution of these gases in moisture or water forms acids (weak or strong acids).Gaseous pollutants are having either acidic or oxidizing in effects on the museum items and even humans (staffs and visitors).

Acidic substances are corrosive in nature and have the following effects on the heritage items:

- Photographic negatives degrade
- Fabrics (cotton, wool, silk, linen) get weakened and brittle
- Iron corrodes
- Formation of acid rain dissolves materials
- And leather loses strength and flexibilities

In the case of oxidizing substances, oxidation reactions take place on the museum items forming acids in organic materials. Oxidants may have these effects on museum artifacts:

- Cracking of rubbers and plastics
- Fading of dyes and pigments
- Paint binder is attacked
- Destruction of items or decay
- Textiles become brittle

Most gases releases into the air is mostly man-made. The gases are released into the air from vehicles, heating systems, factories, and power stations, thereafter finding their route into the library, gallery, archive, and museum buildings.

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Sulphur dioxide (SO_2)
The sources of this gas could be internal or external environments. Few are from indoor sources, but mostly from burning of oil or coal, chemical degradation of natural substances in the environment. Dry deposition of SO_2 was found to be the dominant input mechanism in urban areas. Studies have shown that there could be a significant deposition of $CaSO_4$ from the atmosphere to large gypsum accumulations in more or less pure silicate sandstone (Fassina, 1988). On masonry materials such as many types of sandstone, granite, and brick, dry deposition tends to produce a thin black accumulation. Studies have shown correlations between the amount of this soiling and the dry deposition of sulphur oxides. The difference between the effects of SO_2 and acid rain is, sulphur dioxide comes from local sources while acid rain is the result of long-range transport and chemical transformation of SO_2 from distant sources (Alghazawi, 2015).

Effects on materials are damaged paint and dyes, attacks photographic materials, tarnish metals, embrittle and discolour papers, and reduce the strength of textiles.

Nitrogen Dioxide (NO_2)
This gas could be released through decomposition of cellulose nitrate, gas heating and cooking appliances (indoor). Outdoor, nitrogen dioxide is produced from car fumes. In combination with moisture in the air, nitric acid (HNO_3) is formed. Also in combination with sunlight photochemical smog is formed (ozone (O_3) and peroxyacetyl (PAN). The reaction products do not seem to be present on carbonate stone to the same degree as those of SO_2. NO_2 increases the corrosion rate of calcareous stones in SO_2-containing atmospheres at high (90%), but not at low (50%) relative humidity. Also, NO_2 is a catalyst for oxidation of S(IV) to S(VI) at a pure calcite surface, in the presence of molecular oxygen at humid conditions (RH: 90%). According to Van Grieken (2010), nitrate salts because of their high solubility are transported into the inner part of the calcareous stone, where they undergo phase transformations such as crystallization and hydration, depending on the ambient conditions (temperature and relative humidity). Deterioration occurs due to the cracks in the stone structure.

Effects: induces fading in textile dyes, damages photographic film, and reduces the strength of textiles

Ozone (O_3)
The action of UV radiation on oxygen produces ozone in the stratosphere at a height of 20-30 km. The UV in this reaction is of much shorter wavelength than ever penetrates to the surface of the earth. O_3 has a bad effect on building materials (deterioration) arising from pollution (Alghazawi, 2015). Ozone is a strong oxidizing agent example is its role in the deterioration of

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limestone. It has been shown to accelerate the sulphate formation at a calcite surface in an SO_2 atmosphere.

Hydrogen Sulphide (H_2S)

H_2S is emitted from sewers and septic tanks can cause serious health issues (E-instrument International, 2017). H_2S gas is created and released into the air when wastewater remains stagnant for a long period of time and becomes depleted of dissolved oxygen. Hydrogen sulfide not only causes adverse health effects in exposed populations, it is also responsible for an estimated 50-70% of the sewage pipe corrosion in the United States. This corrosion occurs when hydrogen sulfide gas reacts with the moisture on the walls of the pipe to form a caustic sulphuric acid (H_2SO_4), which corrodes the infrastructure of the sewage system. This corrosion leads to the need for costly pipe repairs and increases the likelihood that additional hydrogen sulfide will be released into the air near offices and homes.

Carbonyl Sulphide (COS/OCS)

This is the most abundant sulphur gas in the atmosphere. Biological processes produce a range of reduced-sulphur gases (Andreae, 1990). Examples are H_2S, CS_2, COS, CH_3SH (methyl mercaptan), CH_3SCH_3 (DMS) and DMDS (dimethyl disulphide). From observation, rainwater is supersaturated with COS so that outgassing may be significant. The analysis of rain and snow samples has shown that COS is produced photochemically in precipitation (Mu *et al*., 2004).

Formic Acid (HCOOH)

Formic acid is a harmful volatile substance. This substance may be from wood products, paints, lacquers and varnishes, glues and adhesives, pesticides, insecticides, fungicides, and adhesive tape. This substance can be harmful on metals, papers, photographic materials, slides, textiles, magnetic tapes and plastics (Scottish Museums Council, 2003). To avoid damages on museum and monuments, careful selection of materials is needed. Always choose acid free paper, polyethylene, polyvinyl chloride, polyethylene foams, polymethylmethacrylate (Perspex), paint-on sealants and glass.

Particulate Pollutants

These are small particles: dust and aerosols. They are part of the outdoor pollution that remains suspended in the air for a very long time. The dangerous ones tend to be small, sticky, black, small, acid particles obtained from the combustion of oil (diesel engines). Particulate pollution can be big and abrasive. They settle on any material whenever the speed of the air is low or still. The particulate is can be so small that it can pass through the tiniest cracks. Large

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particles are easily removed during cleaning, whereas small ones will only settle if they are entrapped or held down by electrostatic attraction (Museums Galleries Scotland, 2017).

Effects on Museum and Monuments

- Particles in conjunction with sulphur dioxide, form acids which causes corrosion and fungal growth.
- Traces of metals in the particles can also speed up the deterioration of organic materials.
- When dispersed into the air and often cause soiling in urban museums.
- Emitted particles darken oil paint films and discolour many dyes and pigments.
- Some materials lose their strength when exposed to alkalis.
- Salt-containing dust particles can support the growth of fungi and micro-organisms.

In some areas, the hostile environment with high **humidity** and the warmth of the sun combined chemically to have a bad influence on the concrete, which most of the outdoor sculptures are made of (Oluwasegun *et al*., 2016**)**. Bacteria, algae, and other organisms that thrive in damp environments have also made homes on many pieces of the outdoor sculptures, and their byproducts are typically corrosive in nature. As erosion occurs, the outer surfaces of the sculptures are chemically altered, especially the fiberglass type, eventually detaching and falling off completely when not remedied. Examples include the *Oduduwa* statue in Ile – Ife (Plate 1), the extinct *Bata* Metal Drummer (Plate 2), Iba Oluyole (Plate 3), Iba Oderinlo (Plate 4) respectively (Oluwasegun *et al*., 2016)**.**

Plate 1: "Oduduwa Statue" (Fibreglass) Inset showing the effect of weather on the shoulder and drapery of the statue, before it was rescued prior the coronation of the new Oba- HRM Enitan Ogunwusi, Ojaja II, Ooni of Ife

Plate 3: By Tiri Oladimeji, *Iba Oluyole* (Cement), Tiri Oladimeji, *Iba Oderinlo*, Cement, Height: 300 m, 1987, Beere, Ibadan. Height: 270 cm, 1991, Mapo, Ibadan. Photograph by Trans Assurance Plc. 1990 Photograph by Akintonde Moses, 2007.

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Plate 2: Bata Drummer (Metal) It Experienced corrosion from the surface and welded joints until it collapsed and it's no more.

Plate 4: By Tiri Oladimeji, *Iba Oluyole* (Cement), Tiri Oladimeji, *Iba Oderinlo*, Cement, Height: 300 m, 1987, Heere, Ibadan. Height: 270 cm, 1981, Mapo, Ibadan. Photograph by Trans Assurance Plc. 1996 Photograph by Akintonde Moses, 2007.

Source: (Oluwasegun *et al*., 2016).

Indoor

These are pollutants which occur within the building. These can be caused by cooking, combustion, the use of chemicals and materials, and animals and human metabolism (Blades *et al*., 2000).Pollutants mainly generated indoors are organic compounds like acetic acid, formic acid, and formaldehyde, which tend to be the most common and damaging, causing corrosion of metals and calcareous materials, and sometimes attacking pigments, paper, and textiles. The organic compounds are with time can build up in a large amount of the materials used in the construction of museum, galleries, libraries, and archives thereby damaging them.

Outdoor

This is a complex mixture of several pollutants like O_3, particulate, NO_2, CO, Pb, Sulphur compound. Due to their harmful effects, they have been regularly measured. The increases in volume of traffic, industries, combustion of coal are the main sources. These harmful gases have effects on marbles, granite, grave monuments, metals. Leather, paper, and textiles

How to Reduce Pollution in Nigerian Museums

Monitoring/Assessments

Although the outside air can carry any number of harmful pollutants, museums can take steps to control and even eliminate most of the dangers posed by air pollution. The Environmental Health Department of the Local Council or a specialist (Chemist) within the museum office should find out the pollution levels in the vicinity. Then, make efforts to protect and care for the collections.

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Table 1: Recommended Exposure Limits of the Pollutants

Pollutants	Items affected Recommendation	
Ozone (O_3)	Paper-based records General museum interiors	13 ppb
Hydrogen sulphide (H_2S)	Metallic objects (Silver materials)	
Nitrogen Dioxide (NO_2)	Textile materials (Color and strength) Photographic materials	5 ppb
Sulphur Dioxide (SO_2)	Photographic materials Textile materials (Color and strength) Papers (Colour and texture) Metallic objects	4 ppb
Formaldehyde (HCHO)	Plastic materials Wood and its products Resin	
Carbonyl Sulphide (OCS)	Metallic objects (Silver materials)	
Formic Acid (HCOOH)	Calcareous materials Metallic objects (Zn, Cu, Pb Other alloys)	
Airborne µg/m^3 Particulate (PM_{10})	General museum interiors (Soiling of museum objects)	75

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Detectors and Monitors

Today, there have been environmental awareness among the global populace. To this effect, there have been global environmental initiatives by companies to protect the environment and to decrease the release of toxic substances into the environment. In this regard, advances in technology, have resulted in the production of simple handheld instruments constructed for the detection, and monitoring of the gas and particulate pollutants. Some of the features of the instruments include sensors, alarm, battery operated, digital display, microprocessor, and others. According to Kumar *et al*. (Accessed, 2017), the instruments could be grouped into the following major categories:

Air Measuring Devices- Volume meters, rate meters and velocity meters.

Concentration Measurement Instruments- For gaseous and particulate sampling.

Meteorological Instruments- Basic devices used for measuring atmospheric variables are included in this category.

Continuous Emission Monitoring Systems (CEMS) - Real-time monitoring of stack gases are the basic thrust behind such systems.

Examples of the portable instruments (Fig 1)

1. Gas monitors (H_2S, CH_4, CO, O_2, Ammonia, Hydrocarbons, Sulphur dioxide, freons, ethylene oxide). CEA Gas Monitors, UniMax Single-Point Gas Monitor, Gasman II
   BC Carbon detectors (CO_2)

   Air Samplers (PM_{10}, $PM_{2.5}$, and TSP, CO, NOx) - MiniVol Portable Air Sampler, PAQS Personal Air Sampler, YES IAQ Monitor.

2. Stand Alone Instruments
   CIC Gas Monitor - Toxic gas (H_2S), Oxygen, Combustible gas.
   ISCO Hydrogen Sulphide Monitor - H_2S
   Single-Point Gas Monitor
   Hazardous Gas Monitor
   BWT Multi-Gas Monitor
   UniMax Safety Area Monitor-Single Gas Fixed Monitor

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Fig 1: **Examples of Portable Instruments**

It is a good idea if parts of these instruments are available in the museums and then handled by competent hands (Environmental Scientist or Chemist) to monitor the environment.

Continuous Emission Monitoring Instruments

These are instruments used in the continuous monitoring of the environment. They are computerized, multipurpose functions (O_2, CO, NO_x, NO, NO_2, SO_2, Rh, F, fpm, efficiency, draft and pressure, temperature, silicon, halogens and other contaminants) fast, and low detection.

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Examples:
GasPlus Combustible Gas Transmitter, TESTO Combustion Gas Analyzer, UniMax Continuous Emission Monitoring, MIDAC Emission Monitoring System, Computerized Stack Sampler.

The Invitation of an Environmental Scientist or Consultant
An environmental scientist is a professional who identifies hazards in the environment - pollution. It is the responsibility of this professional to find ways to reduce or eliminate these hazards. In a museum where it may not be possible to have standby personnel to monitor the vicinity, then the invitation of an environmental scientist is ideal for the monitoring of the environmental situation of the museum both the indoor and outdoor. If the services of the consultant are effectively utilized the artifacts, buildings and people (staff and visitors) will be safe.

Ventilation
Some gases suspended in the air affect and damage the art objects. To safeguard the objects on display against the pollutants, the air in the storage spaces and exhibition rooms must be adequately filtered (Alago, 2010). With the installation of air activated charcoal filter or water spray within the building, SO_2 gas is filtered. By Covering of the objects with lacquer will prevent H_2S.

Natural
Natural and Artificial Ventilation should be taken into consideration before erecting a museum building (Usually towards the wind direction for the exchange of air (stack and fresh).

Artificial
This involves the use of air conditioner, air intake fan, and air filter. Any pollutant within the museum is extracted out instead of concentrating on the building and sticking to the items in the building.

Reduction of traffic
It is suggested that limiting vehicle traffic near historical monuments, may reduce the impact of pollution. In doing this, the levels of SO_2 within the vicinity of the museum and monuments will be reduced (Metallo *et al*., 1995).

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Conclusion

No doubt, Nigeria is endowed with good cultural heritage. The National Commission for Museums and Monuments is doing its best in the conservation of the heritage. From a point of view, the environment where these heritages are kept is polluted both the indoor and outdoor. The gases (O_2, CO, NO_x, NO, NO_2, SO_2) and particulate when in contact with moisture or rain are dissolved and acid rain is formed. This rain causes the damage to most of the monuments. Good ventilation, coverage, paintings, and other methods have been used to prevent their spoilage. It has been suggested that siting of the museums should be far away from traffic dense areas. It is recommended that constant monitoring environment, museums, and monuments should be ensured.

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