Available online at www.jobpcr.com

ISSN-2394:3076
CODEN(USA) : JBPCBK

Journal of Biological Pharmaceutical And Chemical Research , 2020, 7(4): 1-12

(http://www.jobpcr.com/arhcive.php)

MICROBIAL TOXICITY IN DAMAGED CULTURAL MONUMENTS AND INDOOR ENVIRONMENT

Dr. Laxmi Kirana Pallathadka[1], Dr. Harikumar Pallathadka[2*]

[1, 2]Manipur International University*

Corresponding Author: harikumar@miu.edu.in

ABSTRACT

Microbial toxicity and eukaryotic cell contamination from indoor construction products significantly colonized by biocommunities were investigated. Microbial contamination is a crucial aspect of air pollution in indoor areas. It is originated from different types of bacterial and fungal spp., mainly filamentous fungi, growing inside when appropriate moisture is supplied. Biocommunities are global in the biosphere, and their existence always distresses the environment in which they expand. The impacts of biocommunities on their surroundings can be helpful, destructive, or noticeable when it refers to human measure or observation. The most critical impact of these biocommunities worldwide is their capacity to reprocess the key elements that consist of every live organism, primarily carbon(C), oxygen (O), and nitrogen (N). Primary production engages photosynthetic microbes, which consume carbon dioxide from the configuration and transform it into organic (cellular) items. The procedure is known as carbon dioxide fixation, and it composes a substantial part of organic C comfortably provided for the synthesis of cell items. Biodegradation triggers the breakdown of difficult all-natural items too numerous other types of carbon that numerous other microorganisms can utilize. There is no usually happening natural product that some microbe cannot damage down. However, some fabricated substances such as Teflon, plastics, chemicals, and biocides gradually break down. The outcome impact of overlapping aspects identifies the opportunity for the growth of specific biocommunities. The essential variables affecting the development are temperature, wetness, H- Conc., in the atmosphere, oxidoreductive potential, H_2O movement in the atmosphere, together with hydrostatic pressure. The research gives a complete summary of deterioration. The impact of the outside and interior environment on the surface of cultural heritage made of mineral building materials, and much more.

Keywords: Deterioration; elements; temperature; pH; humidity; monuments

INTRODUCTION

Microbial toxic substances are contaminants developed by microbes, including fungi, viruses, and bacteria. These contaminants are necessary venomousness components reputable of microbial pathogenicity and evasion of the host immune response. Fungal toxins are a sort of contaminant that is generated by fungi. The demolition of construction products by biocommunities is a problem for product developers in the present **(Bertron, 2014)**. They may be infected initially with these biocommunities.

Nevertheless, cultural heritage in the appearance of sculptures, paints, frameworks are in danger **(Gadd & Dyer, 2017)**. Interior products are subjected to microbes, yet so are external products. In a comparable method, that inside can be polluted with bacteria. It can usually be thought that all variables are vulnerable or bio-sensitive to biodegradation. It allows us to discover what variables reason microbial corrosion.

Sediment microbes are vital for the biodeterioration of organic substances and the cycling of nutrients even as microbes are liable to contaminants **(Eismann & Montuelle, 1999)**. The biodegradation of organic contaminants in the marine atmosphere is usually done through microbes **(Verrhiest *et al.*, 2002)**. The majority of the microbes in marine ecosystems are bound to sediment elements. For instance, 0.1 mm of Dutch River elements have since massive quantities of microbes as 10 mt of H_2O **(Van Beelen and Fleuren-KemilEURa, 1989)**.

The previous procedure takes place when microorganisms absorb substances for food. The last procedure occurs when microbial metabolites respond with the parts of substances. After that, deterioration, visual alteration to the products, and the discharge of lethal metabolites happen. The capability of microbes to deteriorate the construction product depends upon various variables. Biodeterioration happens in association with the chemical and physical variables influencing the microbes. Microbes use a comparatively broad range of resistance to alterations in environmental circumstances. Below the right circumstances, microbes grow superbly. Below difficult circumstances, they can create the restraint of cell advancement or wounded or cause the demise of the microbes. While permitting the effect of environmental variables on microbes, that is not probably to recognize the essential microbes. The outcomes of various overlapping elements acknowledge the prospect of developing particular biocommunities. The main development aspects are temperature, wetness, concentrate Of H- in the atmosphere, oxidoreduction possibility, H2O motion in the environments, and hydrostatic pressure **(Piontek & Lechów, 2013).**

In specific intractable contaminants, biofilm-moderated bioremediation can be made for utilization in the mix with phytoremediation or with chemical therapies. Still, in numerous other scenarios, microbial consortia of bacteria-fungi might be used in the mix to deteriorate xenobiotic substances. Generally, biofilm moderated bioremediation stays an enticing option in mitigating environmental contamination despite its restraints. **(Mitra & Mukhopadhyay 2016)**.

2. Meteorological and climatic aspects

Climate conditions and meteorological characteristics can affect harmful procedures, such as mechanical distress, desiccation, scaling of surface area, erosion, and breaking, and can accelerate specific chemical assault on products. Climatic aspects containing air temp., sunlight radiation, air moisture, various kinds of precipitation (rains, snow, and others), along with wind speed and directions, are without a doubt essential. The meteorological circumstances affect the transportation, dispersion, diffusion, and deposition of discharges from sources and therefore could control contamination-induced material harm. Additionally, the order of toxins can impact physical procedures in the environment. Enhancing the climatic concentration of CO_2 and other trace gases change air chemistry and impact chain reaction. The greenhouse effect, influenced by CO2

emissions, may increase reactions and promote chemical changes on the material exterior area in an outside environment. SO_2 exhausts have a fresh impact as they backscatter sunshine and create brighter clouds by enabling minor-sized water drops to develop.

2.1Moisture

Moisture and temperature impact the chemical, natural, and mechanical deterioration procedures. The manufacture of the humidity layer on the substance's surface depends on precipitation. It might originate from the reaction of absorbed water by the material surface, deposition fragments by the product surface, and deposition fragments with reactionary gases.

A moisture coating is a medium for surface pollutants' chemical and photochemical responses. It is a well conductive pathway for electrochemical reactions. 2 variants are vital from the views of the harm because of humidity: relative humidity of air and dew point (DWPT). Dew point is a specialty of the water amount of the big air mass, whereas relative moisture depends on the regional temperature and the regional meteorological parameters. When the temperature of a product is under the ambient dew point, water condenses on the product, a humidity coating can form, and the product's damages can continue mainly products and enhance in relative moisture causes much more biodeterioration because of other lengthy wetness time, Greater deposition rates of toxins, and far better conditions for bio-degradation.

Moisture is considered to create significant damages to inorganic construction products. The humidity content and permeableness mainly control the effects of toxins upon the level of climate conditions of the product. The most dangerous element is the cyclic difference of wetness element (moistening and drying out) in the occurrence of hygroscopic salts. The level of drying after moistening relies on situations, for instance, ambient temp, relative moisture, and wind velocity. Deterioration of sandstone generally goes at high relative moisture, over 65%, and is regularly contacted freeze-thaw weathering. The degradation of outdoors wall surfaces prepared from absorptive construction products is triggered by the too much humidity content, mainly following driving rains in addition to disclosure to lengthy-time of humid situations.

2.2Temperature

Temperature impacts the procedure of biodeterioration of a product regularly and in various methods. Modifications in temperature generate a thermal gradient among the surface area layer and the internal layer of products (specifically in products with lesser thermal conductivity), which might damage the mechanical assets of the product and create the development of very thin splits. The making of cracks is encouraged by decreased strength and increased product porosity, reducing the chemical resistance of the things.

Temperature variations of products might impact bulk growth, for instance, the development of sandstone particles development of water in substance capillary.

Enhanced ambient air temperature is amongst the causes why the level of damp removal is most significant for degradation procedures in torrid Zone and subtorrid areas compared to warm locations. Greater ambient temperature lessens the results of freeze-thaw cycles.

An increase in ambient air temperature in a toxic atmosphere can accelerate item degradation because of the enhanced chemical reactions on the product's upper layers. Nevertheless, lessening ambient temperature might increase the probability of degradations. Suppose the item's location temperature level goes down listed here the wetness. In that case, a condensation Layer will also base on the surface area in the presence of contaminations, which will undoubtedly tip-up biodeterioration.

2.3 Solar radiation

Solar radiation produces temperature alterations in items and can modify quantity items in the pores because of the enhanced water heated up through solar radiation. It has an essential function in photochemical reactions because it provides the power for the excitation or splitting bonds in the reacting bits. An ideal focus of solar radiation at appropriate wavelengths is crucial for photochemical work, which impacts the deterioration of numerous structure items. Of the whole energy building aspects of the typical power imposing on the surface on earth, 10% is UV radiation, 45% is visible light, and 45% is IR radiation. The primary materials absorbing UV radiation consist of molecular O_2, oxides of Sand N, and natural substances like Aldehydes (R-CHO). A bit of O_2 is split right into responsive O_2 atoms after the absorption of UV radiation provided right here 240 nm. SO_2 reaches the fired-up state only throughout the absorption of solar radiation at wavelengths of 340-- 400 nm. The oxidation of excited SO_2 in the air creates the generation of SO_3. SO_3 ultimately responds with ambient moisture to establish sulphuric acid aerosol. Unlike SO_2, NO_2 is photochemically very energetic. It uses up solar radiation over the entire recognizable and similarly UV variety. Delighted bits are developed in a spectral option of 380-- 600 nm, and listed here, 43 nm photodissociation happens. Sunshine-made environment photochemical responses amid NOX, natural gases, and vapors generate O_3 as a response product. Ozone (O_3) boosted speed the deterioration of artificial all-natural items took advantage of defensive treatments comparison ecological effect on a diversity of outside consisting of steels, concrete, lumber, and a lot more. O_3 was situated to have an inducement impact on a stratified rock in addition to dolomitic sandstones. Recognizable and UV radiation produce the generation of totally cost-free radicals in wood. Oxidation of these radicals sets up the production or degeneration of radicals, which goes away with the development of low molecular weight materials.

2.4 Wind effect

An enhancement in wind speed might influence the degradation of products in different strategies. Winds drive solid and liquid substances by the air to the product surface. An enhancement in wind velocity might influence the degradation of products in different strategies. Winds drive solid and liquid substances from the air to the product outside, wherever they create location abrasion and provide the product's weathering. Windward wall surfaces are moistened substantially more than leeward wall surfaces throughout rains. On the windward area, wind promotes the infiltration of rainwater and liquid remedies right into permeable products or, throughout various other climate conditions (solar radiation, temperature modifications), sustains desiccation of the airborne component of construction. Both procedures, dampening together with drying, may influence amount modifications in the composition. A significant impact of wind can enhance the transport of sea salt inland, which can dramatically expand the places impacted by water aerosols along shorelines.

3. Results of air contaminants and all-natural climatic components.

In the environment, products take on damages using a collection of physical and chemical communications and all-natural work. Along with ecological loading, disclosure to climatic pollutants speeds up the damages and increases the impact of weathering.

The environment is a combination of gases and solid fragments. Dry air includes 18 long-lasting aeriform components. Among these, N molecular, O, Ar, and CO_2 are the substantial components, while the remaining gases exist in small amounts. The minor components are grouping trace gases considered contaminants: N_2O, CO, NH_3, O_3, NO, NO_2, SO_2, and H_2S. Atmospheric aerosol particles substances of natural sources, dust, minute particle and drops signify liquid and solid setting items. Water can be positioned as water vapor in addition to liquid and solid stages.

The environment is infected with the discharge of various chemicals into the air (primary contaminants) and through chemical procedures, especially airborne (secondary contaminants). Primary contaminants come into the environment through natural resources due to anthropogenic movement. In the environment, they interact with water vapors and water drops, O_2, and various further reactive particles like liquid and solid substances originating secondary contaminants. Among the toxic substances that create degradation, S and N substances deserve as specified mention. It has been revealed which chemicals create the all-natural decrement; nevertheless, it may be difficult to quantify their involvement in that process in a few belongings. Primary and secondary contaminants are transferred, spread, and credited outside a product inside the environment. On the product's surface, contaminants make the reaction here by the substances or by the reactive materials originate externally. The level of direct disclosure, the chemical structure, and the focus of toxins, combined with the quantity of wetness existing externally, identify the adjustments in the product and the degree of damage. The composition and the kind of substance are similarly significant. Together with these, metals' climatic deterioration relies on various additional elements, for instance, the concentration of outside electrolytes and unpredictability in electrochemical responses, the positioning of the steel surface area, and the impact of the safety corrosion layer. Components that trigger biodegradation can exist and depend on each other (Koul & Upadhyay, 2018).

3.1 Elements Affecting the Advancement of Microbes

For many individuals, microbes are out of view and, for that reason, out of mind; however they are a big, incredibly varied team of microorganisms, they are all over and are the leading type of life in the world. Microbes, including our skin, colonize practically every external area; nevertheless, many of them are safe for human beings. Several microbes can survive in steaming warm springs, whereas others develop biocommunities in the frozen sea. Amongst their several functions, microbes are essential for biogeochemical cycling, soil fertility, the disintegration of dead plants and animals, and the degradation of several complicated natural substances existing in the atmosphere. Environmental microbiology is interested in studying soil, water, and air microbes and their function in bioremediation to reduce ecological air contamination through biological degradation of contaminants into biologically safe or much less hazardous compounds. The area of environmental microbiology additionally covers the subjects such as microbially caused biocorrosion, biodeterioration of creating products, and high microbiological quality of exterior and interior air.(Briški & Domanovac. 2017).

The fungus will undoubtedly expand at 40% or extra relative air moisture. Surpassing this range will irreversibly trigger fungus to expand on construction and end up products. It is used in apartments, homes, public centers, and livestock real estate where both pets and individuals exist.

3.2. Techniques for identifying Biocommunities on structure materials.

The complying area intends to provide a detailed listing of the methods used in microbial examinations on construction products. Regarding both samplings and evaluation, just the techniques performed on construction products are observed here. Techniques used A) in-situ and B) in research lab experimentation are explained relating to tasting. While offered, research contrasting the approach's effectiveness relative to construction materials is observed.

3.3 Microbial sampling techniques

Numerous strategies are present for sampling microbial populations on things: swabbing, mass, cellophane tape, contact plate, and a lot more. Nonetheless, the in-situ treatment has not been well typical yet. In addition, though a great deal of these strategies has genuinely been looked into assessing their event capacity in nonpermeable places, a few of the scientists mentioned building

materials such as concrete, treatments, mortar, and plasterboard, which is porous, harsh, and messy products. The "Mould in the house" researchers has launched technical references for sampling upon surface areas of buildings and advise using as a minimum 2 of the sticking to area sampling techniques: swabbing, mass sampling, cellophane tape, and agar contact (imprint strategies) (CSHPF. 2006)

3.4 Swab sampling

Swabbing includes scrubbing a polluted surface using a sanitized swab generally submerged in physical therapy. It is a reasonably low-priced system making it possible for samples to be built up under every circumstance. Swab method is usually picked when cellophane tape and other methods are problematic as a result of problems in reaching the place (Santucci *et al.,* 2007; Beguin, & Nolard, 1994) as circumstances when samples are gathered within wall surface areas or below house window sills (Bellanger *et al.,* 2009; Lappalainen *et al.,* 2001; Ellringer *et al.,* 2000; Reboux *et al.,* 2009; Muynck *et al.,* 2010).

Many scientists clarify the impact of great deals of requirements on the effectiveness of the swabbing technique containing: conducting via an operative, different type of swab is used (Mahouts, 2012; Rose *et al.,* 2004; Edmonds *et al.,* 2008; Edmonds, 2009).

3.5 Bulk sampling

It is a damaging strategy wherein samples are directly taken away from the outside to be reviewed, through scraping, scratching, or coring of tiny particles of the product. Bulk sampling is just among one of the most regularly utilized tasting methods in the microbial exam on building products (Tuomi *et al.,* 2000; Peltola *et al.,* 2001; Brown *et al.,* 2007; Pasanen *et al.,* 2000; Hippelein & Rügamer, 2004; Brown *et al.,* 2009).

Biocommunities can be divided through mass sampling in 2 methods: (i) direct plating of the samples onto a culture media (ii) microbial treatment layering upon a culture media (Miller, 2001).

Final circumstance, mass samples are initially immersed in a physical saline choice or washed by the solvent according to various treatments to eliminate the microbes; dilution activities are next feasible before the plating. Samples can be gotten rid of so regarding be appropriately viewed under a microscope (Andersson *et al.,* 1997).

3.6 Cellophane tape method

A cellophane tape is placed on the infected outer area. This area needs to be level preferably and wholly dried before the sampling. Afterward, it is helpful to inoculate the microbes onto plates using tapes for a solid culture media. (Wiktor *et al.,* 2009) Alternatively, to examine it by a microscopic in organizing to recognize them or execute semi-analysis (Doll, 2002; Yamaguchi *et al.,* 2002; Boutin-Forzano *et al.,* 2004).

3.7 Plates methods

A culture media is straightly pushed alongside the outer area for sufficient duration to permit the sticking together of microbes. After that, Petri plates are shielded by air pollution through a cover and nurtured (Andersen *et al.,* 2011; Bouillard *et al.,* 2005). Some researchers revealed that the extraction of microbes is based on numerous considerations, significant time, and pressure on the Petri plate (CSHPF, 2006, Santucci *et al.,* 2007). Consequently, business applicators usually are created for a specified time and pressure.

3.8 Microbiological culture methods

Microbes can be cultured before different analysis types for measurable or qualitative microbial evaluation of surface areas, relying upon the study. Culture media has a significant influence on the improvement of microbes. As a result of their precise chemical nature, many culture media, known as selective media, can be used to contain different selected spp. By stimulating their growth at the expense of various microbes. Culture-based approaches give essential details on antibiotic-resistant phenotypes, specify both scientific breakpoints and epidemiological cut-off worths, and enable an analysis of multidrug resistance. Numerous approaches are used in culture-based research, and each revealed to give reproducible outcomes with tiny mistakes. A detailed understanding of the ecology of antibiotic vulnerability in the atmosphere needs strategies that incorporate farming with molecular techniques and clarify the connection amid phenotypic and genotypic resistance procedures. (McLain *et al.,* 2016).

In the last few years, researchers have concurred that the unique utilization of culture-based approaches is not enough to qualify an infected region by high precision due to the numerous opportunities for presenting predisposition. These techniques are typically more responsive than other logical techniques to high sampling excellence (Reboux *et al.,* 2009). They identify portions of all the microbes existing in a sample (Rylander, 1998; Lawton *et al.,* 1998).

4. Analytical approaches

Many scientific approaches might be taken advantage of to accomplish measurable or qualitative analyses of microbes on a substratum. The selection of an appropriate method for microbic inquiry is dependent not only on its duration and rate but also on the assessment's objective. The adhering to area specifies the essential logical techniques found in the literary works stressing microbic advancement on framework points: culture-based strategies, observation approaches, chemical techniques, together with molecular biological methods.

Scientific method advancement finally develops major test approaches. These strategies are used in quality assurance laboratories to ensure drug products' recognition, purity, safety, efficiency, and performance. Controlling authorities are positioning a greater focus on practical production methods. Medication approval by regulative authorities asks for the prospect to validate control of the entire therapy of medication reconstruction by using validated practical techniques. (Ravisankar *et al.,* 2014).

5. Chemical strategies

Different chemical techniques can offer much detail about microbes. They are usually utilized to approximate the metabolic task and consequently the poisoning capacity of a microbic populace on a substratum. The importance of techniques, including the number of chemical elements produced from microbic cells, is determined by selecting the elements to be considered. Opportunities are Quantifying the chemical components, including the microbic cells like parts that produce the fungus mycelium cells (Gutarowska, 2010; Pasanen *et al.,* 1999; Szponar, & Larsson, 2000) ATP provides energy and polysaccharide for cell wall (Andersson *et al.,* 1997). The number of substances can be connected to the option of microbes, or it can be called the kind of microbial kind. These strategies stay to remain to be in a similar method expenses when germs stay in a non-active kind.

6. Treatments and monitoring

Biocides and significant barriers to managing radiation or contaminated artwork with physical techniques such as heat still lacked quality tracking methods. The taxon study of microbial places on the artwork, it is generally accepted that not all fungi, except for a tiny portion of Archaea as well as the microorganisms, can be broadened on lab media which molecular techniques based upon

deoxyribonucleic acid(DNA) are vital to take a look at the microbial selection is a problem. (Ettenauer *et al.,* 2012; González and Saiz-Jimenez 2005; Michaelsen *et al.,* 2006; Schabereiter-Gurtner *et al.,* 2001).

Recently, numerous services have, in truth, used luminometers that recognize along with identified ATP in swab circumstances together with assessment of natural action on an area like paper, paints, or various further things (Berthold and Tarkkanen 2013; Rakotonirainy and Arnold 2008).

While these techs provide a rough assessment of microbial activity in general, assessment of gene expression will provide comprehensive details about the metabolic status and the biodegradation process and potential, for example, the activity of cellulolytic keratinolytic enzymes. (Krakova *et al.,* 2012).

CONCLUSION

In the structure of interior air top quality damage set off by microbes, the research study of microbial dispersing on building material is usually suggested exists. **(Stanaszek-Tomal, 2020).**

We find the microbial colonization and visibility of selected potentially unsafe microbial agents in building materials for indoor wall surfaces in a home with moisture problems. Conquered by water-damaged building products and microorganisms lurking inside building constructions are considered as a resource for bioaerosol emissions in homes with mold problems. **(Gravesen, *et al.*, 1994; Johanning, *et al.*, 1996; Sorenson, *et al.*, 1987)**.

In-situ microbial examinations upon constructing products have been executed to offer an improved image of the interior bio-community and recognize potential pollutants related to the owners' health. Different sampling and investigation techniques have been examined in examinations handling the microbic infractions of structure products. Swab tasting, cellophane tape method, and get in touch with plate tasting are approaches originally established in microbiology for flat surface areas and therefore are unsuitable for this type of harsh, porous, dirty products—minority research shown that their effectiveness on concrete program reduced worth contrast to a different type of metals. There is a requirement to adjust and standardize approaches or expand the strategies used to observe the microbial populaces offered on a constructing product surface area as precisely as feasible. Additionally, societies, monitoring, and chemical and molecular evaluations give a wide variety of methodology for microbial analysis based upon the objective of the research study. Standardizations would undoubtedly support the option of methodology by allowing various limitations such as appropriate spp. (if recognized), the purpose of research, the restrictions of detection, and others. The presented research detail the various microorganisms, some potentially poisonous and allergenic, that colonized surface areas relying on various elements like that material kind and humidity. Fungus is most often discovered in interior atmospheres, and every method is applied mutually, are *Cladosporium*, *Penicillium, Aspergillus*, and *Stachybotrys;* the bacteria are Gram-negative bacteria and *mycobacteria*.

REFERENCE

[1] Andersen, B., Frisvad, J. C., Søndergaard, I., Rasmussen, I. S., Larsen, L. S., (2011). “Associations between fungal species and water-damaged building materials," Applied and Environmental Microbiology, *Applied and Environmental Microbiology*, 77(12); 4180–4188.

[2] Andersson, M.A., Nikulin, M., Köljalg, U., Andersson, M. C., Rainey, F., Reijula, K., Hintikka, E. L.,Salkinoja-Salonen, M., (1997). “Bacteria, molds, and toxins in water-damaged building materials," *Appl Environ Microbiol*; 63(2):387-93.

[3] Beguin, H., Nolard, N., (1994). “Mould biodiversity in homes I. Air and surface analysis of 130

dwellings", *Aerobiologia*;10:157e66.

[4] Bellanger, A. –P., Reboux, G., Roussel, S., Grenouillet, F., Didier-Scherer, E.Dalphin, J. –C.,Millon, L., (2009). "Indoor fungal contamination of moisture-damaged and allergic patient housing analysed using real-time PCR, *Letters in Applied Microbiology*"; 49:260-266.

[5] Berthold, F., Tarkkanen, V., (2013). "Luminometer development in the last four decades: recollections of two entrepreneurs," Luminescence 28. doi:10.1002/bio.2459.

[6] Bertron, A., (2014). "Understanding interactions between cementitious materials and microorganisms: A key to sustainable and safe concrete structures in various contexts," Mater.Struct. 47, 1787–1806.

[7] Bouillard, L., Michel, O., Dramaix, M., Devleeschouwer, M., (2005). "Bacterial contamination of indoor air, surfaces, and settled dust, and related dust endotoxin concentrations in healthy office buildings," *Ann Agric Environ Med*, 12(2);187-192.

[8] Boutin-Forzano, S., Charpin-Kadouch, C., Chabbi, S., Bennedjai, N., Dumon, H., Charpin, D. (2004) Wall relative humidity: a simple and reliable index for predicting Stachybotryschartarum infestation in dwellings. Indoor Air, 14(3):196-199.

[9] Briski, F., Domanovac, M.V., (2017). "Environmental microbiology. Physical Sciences Reviews", 1-22.

[10] Brown, G. S., Betty, R. G., Brockmann, J. E., Lucero, D. A., Souza, C. A., Walsh, K. S., Boucher, R. M., Tezak, M. S., Wilson, M. C., Rudolph, T., Lindquist, H. D. A., Martinez, K.F., (2007). "Evaluation of rayon swab surface sample collection method for Bacillus spores from nonporous surfaces," *J Appl Microbiol*,103(4):1074-1080.

[11] Brown, G. S., Betty, R.G., Brockmann, J.E., Lucero, D.A., Souza, C.A, Walsh, K.S., Boucher, R. M., Tezak, M. S., Wilson, M. C., (2009). "Evaluation of vacuum filter sock surface sample collection method for Bacillus spores from porous and nonporous surfaces," *J Environ Monit*.9(7):666-671.

[12] CSHPF., (2006). "Fungal contamination in indoor environments diagnosis, effect on respiratory health, driving! To hold", Superior council of public hygiene of France.

[13] Doll, S. C., (2002). "Determination of limiting conditions for fungal growth in the built environment," Science.Harvard School of Public Health.

[14] Edmonds, J.M., Collett, P.J., Valdes, E.R., Skowronski, E.W., Pellar, G.J., Emanuel, P.A., (2008). "Surface sampling of spores in dry-deposition aerosols," *APPLIED AND ENVIRONMENTAL MICROBIOLOGY*, 75(1)pp. 39–44.

[15] Edmonds, J., (2009). "Efficient methods for large-area surface sampling of sites contaminated with pathogenic microorganisms and other hazardous agents: current state, needs, and perspectives," *Appl Microbiol Biotechnol* 84: 811-816.

[16] Eismann, F., Montuelle, B., (1999). "Microbial methods for assessing contaminant effects in sediments," *Rev. Environ. Contam.Toxicol*. 159, 41–93.

[17] Ellringer, P.J., Boone, K., Hendrickson, S., (2000). "Building materials used in construction can affect indoor fungal levels greatly," *American Industrial Hygiene Association*,61(6): 895-899.

[18] Ettenauer, J., Pinar, G., Lopandic, K., Spangl, B., Ellersdorfer, G., Voitl, C., Sterflinger, K., (2012). "Microbes on building materials evaluation of DNA extraction protocols as common basis

for molecular analysis," Science of the Total Environment, 439:44–53.

[19] Gadd, G.M., Dyer, T.D., (2017). "Bioprotection of the built environment and cultural Heritage," *Microb.Biotechnol*. 10.

[20] Gravesen, S., Frisvad, J. C., Samson,R. A., (1994). "Microfungi, Munksgaard Publishers, Copenhagen, Denmark", 1-168.

[21] Gutarowska, B., (2010). "Metabolic activity of moulds as a factor of building materials biodegradation," *Polish Journal of Microbiology*,59(2):119-124.

[22] Hippelein, M., Rügamer, M., (2004). "Ergosterol as an indicator of mould growth on building materials," *Int J Hyg Environ Health*, 207(4):379-385.

[23] Johanning, E., Biagini, R. Hull,D., Morey,P., Jarvis, B., Landsbergis,P., (1996). "Health and immunology study following exposure to toxigenic fungi (Stachybotryschartarum) in a water-damaged office environment," Int. Arch. Occup. Environ. Health 68:207–218.

[24] Koul, B.; Upadhyay, H., (2018). "Fungi-Mediated Biodeterioration of Household Materials, Libraries, Cultural Heritage and Its Control," In Fungi and Their Role in Sustainable Development: Current Perspectives; Gehlot, P., Singh, J., Eds.; Springer: Singapore.

[25] Krakova, L., Chovanová, K., Selim, S.A., Šimonovičová, A., Puškarová, A., Maková, A., Pangallo, D., (2012). "A multiphasic approach for investigation of the microbial diversity and its biodegradative abilities in historical paper and parchment documents," *IntBiodeteriorBiodegrad* 70:117–125.

[26] Lappalainen, S., Kähkönen,E., Loikkanen, P., Palomäki,E., Lindroos, O., Reijula, K., (2001). "Evaluation of priorities for repairing in moisture-damaged school buildings in Finland," Building and Environment, 36:8,981-986.

[27] Lawton, M. D., Dales, R. E., White, J., (1998). "The influence of house characteristics in a Canadian community on microbiological contamination," Indoor Air, 8(1): 2-11.

[28] McLain, J. E., Cytryn, E., Durso, L. M., Young, S., (2016). "Culture-based Methods for Detection of Antibiotic Resistance in Agroecosystems: Advantages, Challenges, and Gaps in Knowledge," *Journal of Environmental Quality*, 45:432–440.

[29] Michaelsen, A., Pinzari, F., Ripka, K., Lubitz, W., Pinar, G., (2006). "Application of molecular techniques for the identification of fungal communities colonising paper material," IntBiodeteriorBiodegrad 58:133–141.

[30] Miller, J. D., (2001). "Mycological investigation of indoor environments. Microorg. Home Indoor Work Environ. Divers.Health Impacts Investig", Control. London and New York: Taylor & Francis Group.

[31] Mitra, A., Mukhopadhyay, S., (2016). "Biofilm mediated decontamination of pollutants from the environment," *AIMS Bioengineering*, 3(1): 44-59.

[32] Muynck, W., De., Belie, N., De., Verstraete, W., (2010). "Antimicrobial mortar surfaces for the improvement of hygienic conditions," *J Appl Microbiol* 108, 62-72.

[33] Pasanen, A.-L., Yli-Pietila, K., Pasanen, P., Kalliokoski, P., Tarhanen, J., (1999). "Ergosterol content in various fungal species and biocontaminated building materials," *Applied and Environmental Microbiology*;65(1):138-142.

[34] Pasanen, A.–L.,Rautiala, S.,Kasanen, J. –P.,Raunio, P.,Kalliokoski, P., Rantamaki, J., (2000). "The relationship between measured moisture conditions and fungal concentrations in water-damaged building materials," Indoor Air, 10(2); 111-120.

[35] Peltola, J., Andersson, M. A., Haahtela, T., Mussalo-Rauhamaa, H., Rainey, F. A., Kroppenstedt, R. M., Samson, R. A.,Salkinoja-Salonen, M. S., (2001). "Toxic-metabolite-producing bacteria and fungus in an indoor environment," *Applied and Environmental Microbiology*,67(7) 3269–3274.

[36] Piontek, A., Lechów, H., (2013). "Deterioracja Elewacji Zewn˛etrznych Wywołana Biofilne. Zesz", Nauk. Uniw. Zielonogórskiego, 151, 79–87.

[37] Reboux, G., Bellanger, A. P., Roussel, S., Grenouillet, F., Sornin, S., Piarroux, R., Dalphin, J. C., Millon, L., (2009). "Indoor mold concentration in Eastern France", *International Journal of Indoor Environment and Health*,19(6); 446-453.

[38] Rakotonirainy, M.S., Arnold, S., (2008). "Development of a new procedure based on the energy charge measurement using ATP bioluminescence assay for the detection of living mould from graphic documents," Luminescence 23:182–186.

[39] Ravisankar, P., Gowthami, S., Rao, G. D., (2014). "A review on analytical method development," *Indian Journal of Research in Pharmacy and Biotechnology*, 2(3);1183-1195.

[40] Rose, L., Jensen, B., Peterson, A., Banerjee, S.N., Arduino, M.J., (2004). "Swab materials and Bacillus anthracis spore recovery from nonporous surfaces," Emerg Infect Dis 10 (6)1023-1029.

[41] Rylander, R., (1998). "Microbial cell wall constituents in indoor air and their relation to disease," Indoor Air, 8(S4):59-65.

[42] Santucci, R., Meunier, O., Ott, M., Herrmann F, Freyd A, de Blay F., (2007). "Contaminationfongique des habitations: bilan de 10 annees d! 'analyses", *Rev Fr Allergol Immunol Clin*;47:402-408.

[43] Schabereiter-Gurtner, C., Pinar, G., Lubitz, W.Rolleke, S., (2001). "An advanced molecular strategy to identify bacterial communities on art objects," *J Microbiol Methods*, 45:77–87.

[44] Sorenson, W. G., Frazer,D. G., Jarvis, B. B., Simpson, J., Robinson, V. A., (1987). "Trichothecene mycotoxins in aerosolized conidia of Stachybotrysatra. *Appl. Environ. Microbiol*", 53(6):1370–1375.

[45] Stanaszek-Tomal, E., (2020). "Environmental Factors Causing the Development of Microorganisms on the Surfaces of National Cultural Monuments Made of Mineral Building Materials—Review," Coatings 10:2-19.

[46] Szponar, B., Larsson, L., (2000). "Determination of microbial colonisation in water damaged buildings using chemical marker analysis by gas chromatography e mass spectrometry," Indoor Air, 10(1):13-18.

[47] Tuomi, T., Reijula, K., Johnsson, T., Hemminki, K., Hintikka, E. –L., Lindroos, O., Kalso, S., La.¨ P. K. –K.,LA, H. M.H.,Haahtela, T., (2000). "Mycotoxins in Crude building materials from water-damaged buildings," *Applied and Environmental Microbiology*, 66(5);1899–1904.

[48] Van Beelen, P., Fleuren-Kemil€a, A.K., (1989). "Enumeration of anaerobic and oligotrophic bacteria in subsoils and sediments," *J. Contamin. Hydrol*. 4 (3), 275–284.

[49] Verrhiest, G.J., Clement, B., Volat, B., Montuelle, B., Perrodin, Y., (2002). "Interactions

between a polycyclic aromatic hydrocarbon mixture and the microbial communities in a natural freshwater sediment," Chemosphere 46 (2), 187– 196.

[50] Wiktor, V., De, Leo. F., Urzì, C., Guyonnet, R., Grosseau, P., Garcia-Diaz, E., (2009). "Accelerated laboratory test to study fungal biodeterioration of cementitious matrix", IntBiodeteriorBiodegr, 63 (8), 1061-1065.

[51] Yamaguchi, N., Ishidoshiro, A., Yoshida, Y., Saika, T., Senda, S., Nasu, M., (2002). "Development of an adhesive sheet for direct counting of bacteria on solid surfaces," *J Microbiol Methods*, 53(3):405-410.