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RESEARCH ARTICLE OPEN ACCESS

Adapting Sustainable Materials for Interiors - Pre & Post Covid Scenarios and Applications

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ABSTRACT
The COVID-19 pandemic has inevitably altered the way we design sustainable interiors, with design strategies now focusing on relying on eco-friendly materials with appropriate design solutions. There is a new focus in the design field on creating easy-to-sterilize environments while ensuring the interior environment promotes well-being and optimal healing. Designers are now exploring, addressing, and experimenting on the development of innovative sustainable materials with the potential of enhancing and promoting an ideal interior environment, through the appropriate selection of sustainable materials. The research paper thus aims to explore the advancement of sustainable materials for floor and wall finishes in the COVID scenario by comparing various properties such as Indoor Air Quality (IAQ), Porosity, Anti-Bacterial resistance, Acoustics, Maintenance & Life Cycle which are key factors for the interior environment. It further develops a comprehensive analysis of the progression and evolution of the sustainable materials from the pre to the post COVID scenarios. The research paper opens a pathway for the creation of innovative materials by rectifying changes analyzed through this research.

Keywords: - Environmentally Sustainable Interior Design (ESID); Building Microbiome; Indoor Air Quality (IAQ); Porosity; Maintenance.

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I. INTRODUCTION

1.1 Role of Sustainability in Design.

Traditionally, the interior design has focused on a one-dimensional practice, providing aesthetic improvements to a client's interior environment.However, in recent years, interior design practice has undergone a significant transition, with design techniques now focusing on providing human with healthy and sustainable settings.

ESID is based on sustainable design ideas and practices that apply to the entire built environment, namely providing physically and psychologically healthy interior settings. Sustainable design takes a more holistic approach, focusing on the planet's health, safety, and welfare so that current generation may satisfy their needs without jeopardizing future generations' ability to meet their own.

According to General Services Administration (GSA) the fundamental objectives of sustainability are: -

- Create healthy environment for users.
- Minimize waste.
- Reduce the usage of non-renewable resources. (Administration, n.d.)

The aspect of sustainabilityis involved in interior design fieldwith factors such as determining efficient and effective use of space, selecting interior materials that offers low environmental impact and lowers pollution, waste, and energy consumption. As per Energy Policy Act (EPAct) it is estimated that ecologically designed spaces are 30% energy efficient than other conventional designs.Sustainability touches every design arena, such as aesthetics, safety, comfortability, and psychological influence of the space, to build a better future. Sustainability in design is not a luxury, it is a necessity.We just cannot afford to continue living as though the Earth's resources are limitless. (Administration, n.d.)

1.2 Scope of Research.

The Research paper aims on how the approach to design and the use of sustainable materials in interiors has changed in the post-COVID era. In this paper, we analyze various sustainable wall and flooring materials based on characteristics such as Indoor Air Quality (IAQ), Porosity, Anti-Bacterial

resistance, Acoustics, Maintenance & Life Cycle, which are critical factors to consider during a pandemic. A pathway for further development of innovative techniques and materials in design to address the post-pandemic era opens with this research.

II. THEORITICAL BACKGROUND

2.1 Historical Background: - Influence of Pandemics on Design Developments.

Pandemics and traumatic events have always had an impact on surroundings. Various earlier epidemics influenced environment before COVID-19, in terms of city planning and dwelling interiors, and there were several architectural and urbanization developments in the last two centuries.During pandemics, the form of design has always followed the dread of infection, just as much as the function.

The bubonic plague (Black Death) was a 14th-century pandemic that ravaged Europe and Asia. In Italy, the plague was a human tragedy unlike any other. It stunned as well as transformed Italian society. The impact of the epidemic, both directly and indirectly, brought in the Renaissance, one of history's most important periods for major urban changes.

In the twentieth century, tuberculosis, typhoid, Spanish flu, and other flu varieties spread across Europe and the United States due to overcrowding and unclean living conditions. The discovery of infectious tuberculosis by physician Robert Koch sparked the sanatorium movement. Sanatoriums were created to accommodate, treat, and isolate patients, with a focus on strict hygiene and plenty of sunlight and air. Modernist architects saw design as a means of healing, which resulted in the birth of modern architecture. From the 1920s until the 1970s, modern architecture was the dominant mode of design, and it was typically simplified to a set of principles affirming purity of form, rigorous geometries, clean, smooth surfaces, modern materials, and a rejection of adornment. Terraces, balconies, and flat roofs are common features in modernist design, even in temperatures that are not conducive to relaxing outside. These characteristics embodied modernist preoccupations with the healing effects of light, air, and nature, in addition to their aesthetic appeal. This period's architecture provided an antidote to disease and trauma.

Figure 1 TuberculosisSanatorium in Wales. (Reeves, 2014)

Le Corbusier recommended people to declutter their homes, get rid of carpets and heavy furniture, and keep the floors and walls free of clutter. He envisioned a spartan metropolis in 1925, where every dwelling is whitewashed and has no dirt or dark corners. This aesthetic is embodied in his ultra-modernist Villa Savoye. Its living quarters are painted clinical white and suspended on columns above the germ-infested earth below. (Chang, 2020)

Figure 2 The Villa Savoye on the outskirts of Paris.(Chang, 2020).

Cholera and typhoid fever impacted the sanitary reform movement during the industrial age. These epidemics influenced the development of modern sanitation and sewage systems to combat germs. Raw sewage used to pour out of buildings and directly into the streets before indoor plumbing and sewer systems were prevalent. It wasn't until a catastrophic cholera outbreak in London in the 1850s that a physician was able to prove that the deaths were caused by tainted drinking water. The prevailing view prior to that was "miasma," the medieval belief that sickness was spread through contact with "poor air," such as vapors emitted by rotting organic materials. This sparked a sanitary reform movement, which resulted in the construction of drinking water and sewage infrastructure. This

global movement resulted in roadways that were straighter, smoother, and wider to install underground pipe networks that could be washed down. (Budds, 2020)

Pandemics such as cholera and typhoid have also influenced Victorian style. Victorian bathrooms were previously designed in the same way as other rooms in aristocratic homes, with carpet, draperies, and wooden cupboards. In the late 1800s and early 1900s, removing those items became fashionable. Companies marketing flooring and wallcoverings capitalized on the belief that smooth, impervious surfaces were healthier than carpet and textiles at the turn of the twentieth century. Materials like porcelain, tile, and linoleum became popular inareas where germs were most prevalent, such askitchens, bathrooms, and laundry rooms. (Budds, 2020)

Figure 3 Victorian bathrooms were once lavishly furnished with drapes, carpet, and decorations like other rooms. The sanitary reform movement changed that. (Budds, 2020).

2.2 Building Microbiome Study.

An integrated ecosystem is made up of the built environment, residents, and microbiomes. The built environment (BE) harbors diverse microbial populations including viruses, bacteria, fungi, and protozoa which collectively constitute the microbiomes of the built environment (MoBE).Humans interact extensively with microbiomes found in the air circulating in buildings, in the water running through plumbing systems, and on surfaces ranging from the most inaccessible to the most touched.

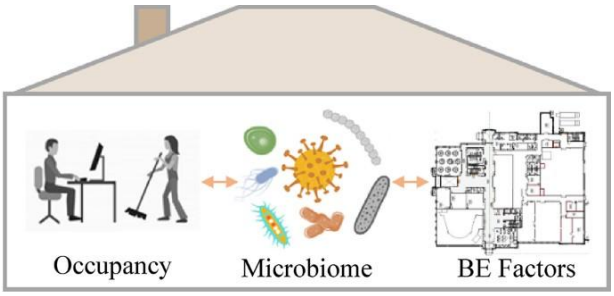

Figure 4 Integrated ecosystem of Built Environment & Microbiome. (Li, Yang, Hu, & He, 2021)(Page No. – 1)

People in wealthy countries spend roughly 90% of their time indoors (Li, Yang, Hu, & He, 2021).People in emerging countries will certainly spend more time indoors as urbanization and modernization progress. As a result, the bulk of microbiomes met by most humans throughout the course of their lives are those found in the built world.

In research on COVID 19 transmission in China, just two instances out of 7300 were found to have been transmitted outdoor. As a result, the built environment is regarded as a significant venue for coronavirus transmission. The built-environment microbiome has both beneficial and harmful effects. A healthy indoor microbiome not only keeps us healthy but also improves our well-being. For example,in the cases of asthma, allergic sensitization, and wheezing in children, various microbial relationships with potentially protective benefits have been discovered.Design components and occupant preferences could introduce beneficial microorganisms, while harmful microbes could be avoided. Currently, avoiding dangerous microbial exposures is more practical. Currently, avoiding dangerous microbial exposures is more practical.The Building Microbiome System is critical in controlling SARS-CoV-2 transmission indoors.

The built environment (BE), which serves as a reservoir for a variety of microorganisms provide an environment for microbial colonization, succession, and transmission. The microbiomes of the built environment (MoBE) are influenced directly and indirectly by factors like as building layout, HVAC, building materials and sunlight exposure.

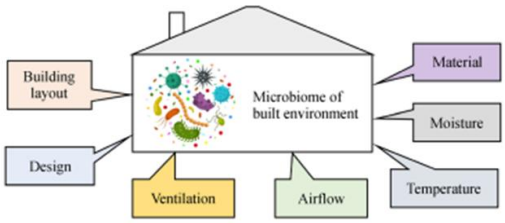

Figure 5 Impact of BE attributes on MoBE. (Li, Yang, Hu, & He, 2021)(Page No. - 5)

Airflow & Ventilation.

Air is a crucial transport vehicle for microorganisms and their metabolites in the built environment because it connects surfaces, water, and dust to what occupant's inhale, or absorb through their skin. Mechanical and natural ventilation are important components in the air transport of indoor and outdoor microorganisms.

Mechanical ventilation includes HVAC system that meet important thermal, and ventilation needs in buildings. HVAC systems provide routes for the entry of outdoor bio aerosols into buildings, as well as a means of circulating and dispersing indoor airborne contaminants. These systems also affect temperature and moisture conditions throughout a building's interior spaces and within interior and exterior walls which in turn affect the state of the indoor microbiome. Particle filtration is used in most ventilation systems, either at the outdoor air intake or in mixed airstreams of outdoor and recirculated air from occupied spaces. Filter type, particle size, and airflow rate all influence the efficiency with which particles are removed.

For ages, natural ventilation has been employed to bring fresh air into buildings and circulate it throughout the interior. When wind speeds or indoor–outdoor temperature differentials are large enough, it allows for increased levels of outside air to cleanse indoor contaminants. Natural ventilation, on the other hand, can allow impurities and moisture from the outside in.

The ratio of window opening size to floor area; the ratio and locational relationships of openings to each other, as well as their relative placements in the room; and the influence of wind velocity and direction on air distribution in the room are all important design considerations. Door openings can also have a considerable impact on the volume of outside air that enters a building, particularly in commercial structures. (Li, Yang, Hu, & He, 2021)

Sunlight.

Sunlight is another attribute that affects microbiomes. The antiseptic action of sunlight has a detrimental impact on the survival and activity of bacterial or fungal monocultures. The quantity of living bacteria in the Built Environment (BE) can also be reduced by visible or UV light, resulting in fewer human-associated bacterial communities. Microbial activity would be lower in areas of the Built Environment (BE) with more sunlight exposure, which is a desired outcome when microbial control is a concern.

Building Materials.

Building materials can also be colonized with microbial organisms. Aspergillus species are commonly found on ceramic-like materials, as well as paint and adhesive surfaces.Building materials based on gypsum promote the growth of Stachybotrys, another indicator of microbial colonization selectivity. (Li, Yang, Hu, & He, 2021)

Bio-based building materials are susceptible to mold growth with chipboard being the most susceptible, and wood the least, while plant aggregates make earth-based materials more susceptible.According to certain research, high copper levels in pipe materials prevent Legionella from surviving and growing in indoor plumbing systems. Metal nanoparticles have been put into a large number of interior surfaces, including textiles, to inhibit fungal and bacterial growth.

Green roof and green wall themes have recently been implemented into built environment. It is possible that the plants introduce microorganisms, moisture, and nutrition that encourage microbial growth. Indoor plants are recognized to contribute significantly to microbial richness and variety and also improve air quality in the Built Environment.

Materials properties, in combination with lighting, heating, cooling, humidity, and ventilation, as well as people and their activities, can have a significant impact on the microbiomes of the built environment (MoBE). Microbial colonization can be aided by the qualities of building materials in two ways. To begin with, building materials can serve as possible substrates and nutrients for colonized microbiomes.For example, cellulose-based materials are more sensitive to microbial colonization and growth than inorganic materials like gypsum, cement, and concrete because they can be digested by a variety of microbial populations. The addition of carbon sources or emulsion paint has been shown to give possible microbial growth substrates. Secondly, most building materials, such as wallpaper glue, paint, grease, papers, textiles, and wood products, have high porosity and surface roughness. Surfaces with a rough and porous texture may facilitate the adhesion of dust and organic compounds resulting from the building's activities. Porous materials may also retain sufficient moisture. As a result of the increasing amounts of organics and moisture, rough

and porous construction materials may stimulate microbial development. However, it has been suggested that if microorganisms are retained in porous materials, they may become immobilized, decreasing their chances of subsequently interacting with the built environment (BE).

2.3 COVID 19 & Transformation of Design.

COVID 19 has changed the way we live and work in built environment. Pandemic had the most immediate impact on physical health and serious implication for emotional and social functioning of users. Pandemic has already changed surroundings through architecture, design, and urban planning.

The coronavirus spreads swiftly and does tremendous damage, much like computer viruses do within a network. It is normal practice in the digital world to build and include solutions that can aid in the prevention of viral attacks; for each new generation, a new security layer is added to ensure that the ever-mutating computer viruses do not destroy the digital structure. Similarly, designers and architects are redesigning or remolding the built environment to make it virus resistant or to lessen the impact of pandemic on users.

In a post-COVID world, homes no longer function the way they should in terms of aesthetics although it cannot be entirely ignored. The importance of easy sterilization of surfaces, private work areas, access to shared areas for family recreation, and greater connections with nature - all within homes is now recognized. The coronavirus outbreak has heightened corporate interest in repurposing space to resemble nature, improve air filtration systems, and employ more environmentally friendly materials. Human-centered design concepts are focused on post COVID to fulfill users' needs and enhance their quality of life. Open spaces (courtyards, gardens, green roofs) are now considered the new "luxury". Plants and natural materials help give the building a cozier touch and improve mental health during house quarantine. Green spaces can help to prevent mental disorders and depression, which can occur during pandemics. To promote natural ventilation and light, buildings are adding open areas and natural light into the interiors.

Advanced technology is being used to minimize physical contact and prevent the transmission of COVID, such as voice-activated elevators, smart building materials, automatic doors, and cell phone-controlled hotel rooms.

2.4 Sustainable Materials for Flooring & Wall Finishes.

Absolute choices of materials are a key element which elevates the character of space. The material selection and decision process has become more crucial in design after the pandemic. In post-pandemic world, material decisions are only set to increase in importance in the eyes of everyone from the architect and interior designer to the end user.A sustainable flooring product has a lowVolatile Organic Compounds(VOC) content and leaves a small carbon footprint. Flooring of this type uses less chemical treatment in the finishing and installation process, reducing the release of harmful toxins into the air. Significantly, environmentally friendly flooring improves indoor air quality by lowering dust levels. The following are some examples of environmentally friendly flooring materials: -

Figure 6 Various Flooring Materials. (Mckenna, 2021)

Bamboo.

During the pandemic, bamboo floors and wall treatments have gained popularity as people seek antimicrobial, sustainable, and environmentally friendly materials. The material is naturally resistant to abrasion caused by footwork and falling objects. The grass fibers in strand woven bamboo are woven together in an interlocking pattern, making it stronger than other bamboo flooring types. Bamboo floors require relatively little maintenance. Bamboo is an extremely lightweight material. The material is appropriate for high-traffic spaces. They offer a natural and contemporary aesthetic. Additionally, bamboo is a highly sustainable resource that grows at a rapid rate. A variety of bamboo shades can be found to complement different decors as well.

Cork.

Cork is made from the bark of the cork oak, a Mediterranean slow-growing tree that lives for an average of 200 years. The ability of the cork oak to regenerate is a valuable property. As a result, no trees are felled or permanently damaged in the cork harvest. Furthermore, a peeled cork tree binds more Carbon dioxide than a tree that has not been peeled. Cork has a distinct appearance, making it the most preferred wall and flooring option. Cork flooring is

well-known for its acoustic properties. Cork has the structure of a honeycomb and boasts a staggering number of air-filled chambers. The sound in the room is swallowed by the air in the cells. Walking on a cork floor is good for your health and posture. They are exceptionally long-lasting and lightweight. They also act as a natural insect repellant and are fire and water resistant. It also possesses antimicrobial qualities, which aid in the reduction of allergy issues within the space, making the built environment safe and sanitary. Cork is warm in the winter and cold in the summer due to its limited thermal conductivity.

Cork, like wood, can be painted or stained in several colors and styles to match any color scheme or design style. It can also be used with other materials to create different types of flooring.

Luxury Vinyl Tiles (LVT).

Luxury vinyl tile (LVT) offers a wide range of performance benefits, making it a good fit for practically any consumer lifestyle and any space. It assures consumers that they are simple to clean and maintain, resulting in health and safety benefits. One of the key drivers of LVT is high performance. LVT is resilient, easy to install and resistant to scratches, stains, and dents. Vinyl's water resistance is a key feature that distinguishes it from the competition.

Luxury vinyl tile can be used to create a wide selection of designs. Because the designs are aided by technology, it is becoming easier to make realistic designs in a variety of species, patterns, and size.

Ceramic Flooring.

Recently, ceramic flooringhas become a popular flooring material. The material is naturally non-toxic: prolonged heating at temperatures above 1,200°C destroys any dangerous biological residues, such as VOCs and other petroleum derivatives. The firm, solid surface of ceramic tiles does not attract or hold dirt, dust, pollen, or other allergies. When microscopic particles fall on a ceramic floor, they stand out against the surface, making them easy to clean away with a mop or sponge. These tiles are one of the most cost-effective flooring options available.

Markets have recently seen the application of ceramics with microban technology. Titanium dioxide enriched with silver is used in the Active Antibacterial Ceramic slabs to combat all types of bacteria, including antibiotic-resistant bacteria (MRSA). Silver's photocatalytic characteristics are activated by natural light or LED, which initiates a strong oxidizing reaction that results in the transformation of toxic organic and inorganic molecules into harmless ones. Microban technology kills up to 99.9% of bacteria on surfaces for the duration of the tile's life cycle, eliminating the need for bleach and frequent wipe-downs.

Wood Flooring.

Wood is a sustainable and eco-friendly building material. They require less energy and natural resources to create, as well as using fewer raw materials. This is a great flooring solution that provides both durability and luxury.

Using reclaimed wood is eco-friendly since it repurposes wood from old warehouses, dismantled houses, underground piers, etc. It keeps the wood from rotting or ending up in landfills, it reduces the need to plant and harvest more trees, and it perpetuates the reduce-reuse-recycle formula, which is an essential part of the sustainability equation. Reclaimed wood meets the "Materials & Resources" criteria for LEED certification since it is recycled.

FSC certified hardwood is another suitable option. They support global forest management that adheres to strong social and environmental norms. The FSC-certified wood has the same durability as traditional wood flooring, plus the ability to sand out scratches and marks. Additionally, it earns high marks on the green scale.

Concrete Flooring.

Polished concrete is gaining popularity as a unique sustainable material. It is also a viable material for interiors, where it can be polished, etched, or stained to serve as finished flooring. Under high traffic conditions in commercial spaces, concrete can last for decades. A concrete floor can look very elegant and colorful. When properly maintained and installed, concrete floors are incredibly strong and durable. They are also relatively inexpensive. From creating a tiled effect with varied colors to inlaying other materials such as glass, the design possibilities are endless. Concrete is simple to maintain and never need replacement.

Linoleum.

Linoleum is a type of flooring made from linseed oil, cork dust, tree resins, wood flour, colors, and crushed limestone. Linoleum is naturally antibacterial, as well as anti-static, which means dust and filth will not stick to it. It is extremely long-lasting and completely biodegradable. A wide range of bright, colorful hues is offered, as well as a new stain-resistant sealant. It has a lengthy shelf life and can withstand a lot of wear and tear. It is fire-resistant and water-resistant, like cork.

Recycled Rubber.

Rubber flooring is made from recycled tires. Worn-out tires are shredded or broken up, the steel belting is removed, and they are reused into high-

cushioning flooring rolls. Rubber flooring contains up to 91 percent recycled content that would otherwise be burned or disposed of in a landfill. It is most encountered in the local gym and other spaces. As a versatile, elegant, and long-lasting alternative, it is steadily making its way into our kitchens, sunrooms, and bathrooms. Rubber flooring is comfortable to walk on and is water-resistant. It is also available in a number of different colors and patterns.Rubber flooring is very simple to install and offers greater cushioning for users than other options.

Glass Tiles.

Recycled glass bottles and wine bottles are used to make glass tiles. As a floor, bathroom, and kitchen wall covering, this renewable resource is increasingly gaining favor. Many of the benefits of glass are like those of other environmentally friendly materials. It is non-absorbent, so it will not mildew or mold in humid conditions. It is easy to keep clean and will not stain. Glass comes in a nearly endless number of colors, patterns, and finishes, making it suitable for almost any design concept. Glass, unlike ceramic tiles, will reflect rather than absorb light, offering that extra layer of light that some interiors require.

Wool Carpets.

Carpet has always been a popular choice for most interior design projects. It is soft to walk on, plush to sit on, and available in a variety of colors and designs. Wool is a popular carpeting material. Wool is a naturally occurring resource that can be spun into a thread and dyed any color before being woven into a carpet. It was one of the first materials to be used as a floor covering, and it is extremely durable, lasting hundreds of years. Sisal, jute, and cotton are examples of natural materials used to produce carpets or rugs.

P.E.TBerber Carpets.

Polyester (P.E.T) Berber is another option for a long-lasting carpet. It is made from recycled plastic bottles and has a low environmental footprint. Every plastic bottle used to produce this carpet means fewer will wind up in landfills. This recyclable material has a few advantages. It is long-lasting, spill-proof, and available in a variety of appealing colors and patterns. It is a very cost-effective substance. Its flecked appearance makes it suitable for a wide range of color schemes.

In interior design wall finishes play a vital role in making the design a success. Wall finishes does not only make the space beautiful but will also elevate the overall experience of the design. Some of the examples of environmentally friendly wall finishes are as follows: -

Figure 7 Various Materials for Wall Finishes. (Mckenna, 2021)

Limewash.

Limewash is a great environmentally friendly option as it is not manufactured with synthetic chemicals, which can be harmful to the environment Limewash is a water-based lime putty made from crushed limestone that has been burned. After aging, the putty is diluted with water and colored with natural colors. Limewash generates uneven, matte surfaces with a chalky feel that resembles suede. It gives flat walls a sense of depth and brilliance.

Limewash blends well with natural construction materials like stone and brick. It also improves the quality of life in our houses. Lime's high pH makes it impossible for microbes to live, making it hypoallergenic. Limewash contains a chemical composition that eliminates odors (as well as dangerous Carbon dioxide), hence enhancing indoor air quality.

Limewash comes in an off-white base color. Natural, alkali-resistant pigments are used to give color, and they come in a variety of colors. The most common colors are browns, grays, and taupe.

Recycled Paper Tiles.

Paper Tiles are manufactured from a local clothing factory's discarded pattern paper. The tiles are as durable as boards, as light as cork, and can be printed or painted in the same way that paper can. They offer excellent sound absorption properties and are simple to install. Tiles come in a variety of forms, colors ranging from natural browns to bleached whites, and printing options. Paper tiles have been found to perform as well as some acoustic foams on the market in acoustic testing. Wave dispersion further minimizes sound reflection when textured tiles are used. In residential and commercial places such as restaurants and offices, the tiles attenuate noise while also functioning as insulators and contributing to relaxing acoustics. Paper tiles can be used as a simple accent with a few tiles or a bold, sound-absorbing treatment that spans a full wall.

Recycled Wool Felt Covering.

Another environmentally friendly option is wool felt wall covering. A felt wall finish or panel absorbs sound well and breaks up sound waves that are reflected. For areas with a lot of hard and bare surfaces, a felt wall is a great and easy option. Wool has a 10% higher insulating factor than cotton and can absorb, hold, and release moisture while maintaining its thermal qualities. Wool is also naturally flame-retardant, sound-deadening, non-toxic, and biodegradable. Wool can improve the quality of your indoor air by absorbing hazardous substances including formaldehyde, nitrogen oxide, and sulfur dioxide. Wool Felt is available in a variety of hues.

Recycled Glass Tile Mosaics.

Recycled glass tiles are created by melting waste glass in furnaces heated to a temperature exceeding 2000 degrees Fahrenheit. After that, the molten glass is stamped into shape, hand-trimmed, and ground to its final shape. The most appealing feature of glass tile isits attractive appearance. Glass tile comes in a wide range of colors and styles, with some manufacturers even allowing you to choose between a smooth edge and a rustic cut for varied textural effects.

Glass tile is chemically and moisture resistant, making it an excellent choice for the kitchen or bathroom. Glass tile is a long-lasting and simple-to-care-for material. As glass tile reflects light and makes rooms appear larger and brighter, it is a good choice for small or dark places. It can also assist diffuse natural light around rooms with a lot of it.

Tadelakt.

Tadelakt, a Moroccan plaster, is a centuries-old answer to our modern desire for environmentally friendly interiors. Tadelakt is an ancient solution to our present requirement for ecological interiors, constructed of hydraulic lime and sealed with olive soap. Tadelakt is applied without the use of harsh chemicals, and its smooth, water- and mold-resistant finish makes it ideal for bathrooms, wet areas, and kitchens. Tadelakt lends itself to a variety of embellishments, including stencils, graffiti, and so forth. Because of its flecked appearance, it goes with a variety of color schemes.

Clay Plaster.

Clay plaster is a decorative wall finish manufactured from widely available natural materials and mineral pigments in a wide range of hues. Formaldehydes and volatile organic compounds (VOCs) are not present in clay plaster. It can be utilized practically in any setting. Excess moisture can be absorbed by clay plaster. It also offers a long list of benefits for indoor air quality, including evidence of mold, bacteria, asthma, and formaldehyde reduction.

Organoid.

Organoid provides surfaces made from organic materials such as flowers, plants, seeds, and coffee that can be used in a variety of ways. What's more, they're all perfumed differently depending on the material they're constructed of. They can be utilized as wall panels or as components of furniture. Even though they are composed of plants, they can withstand fire.

They offer some fantastic additional value in addition to the exceptional looks they provide to any interior. First, as previously stated, the perfume saturated with memories of our natural environment can have a calming and positive effect on our mood and concentration. Second, they feature acoustic absorption capabilities, making them ideal for quiet settings like study rooms or co-working spaces.

Anti-Microbial Paints.

Capa Care Protect is a product manufactured by Caparol, a German paint company. Capa Care Protect is a 100% acrylic water-based emulsion paint finish that provides total antimicrobial protection. Capa Care Protect is made with a proprietary Silverbac technology that prevents viruses and bacteria from growing on the coated surface, reducing the transmission of contagious diseases.
Capa Care Protect is formaldehyde-free, odorless, easy to clean, extremely washable, and has great water barrier qualities as well as being fire resistant. It also improves the quality of indoor air.

2.5 Factors Influencing the Material Selection during COVID.

Every decade is defined by a distinct style of architectural and design aesthetics. This decade's design trend is defined by our adaptation and response to the epidemic. The pandemic has created new requirements in our personal, professional, and public places, which has inspired and transformed interior design and space planning.

COVID-19 viruses can persist on material surfaces outside of the human body. On all surfaces, the virus behaves differently. Therefore,it is critical to reassess and make necessary changes to the building materials used. Indoor Air Quality (IAQ), Porosity, Anti-Microbial Resistance (AMR), Acoustics, Maintenance & Life Cycle are considered as crucial factors for materials used in the post COVID era. (EPA, n.d.)

Indoor Air Quality (IAQ).

Indoor air quality is critical to one's health, especially nowadays when people spend up to 90%

of their time indoors. As the need to isolate in homes during COVID-19 to prevent the virus from spreading, indoor air quality has deteriorated (IAQ). As COVID-19 can be transmitted through the air, maintaining adequate indoor air quality is critical.
Volatile organic compounds (VOCs), such as formaldehyde, are an important class of indoor contaminants that can evaporate under normal atmospheric circumstances. Interior building materials could be a significant source of IAQ pollutants. Interior building materials, including as carpets, carpet padding, paints, sealants and caulking, adhesives, floor and ceiling tiles, cabinets, molding, composite wood products, and other woodwork, might contain toxins that are slowly released (off gassed) over time. As a result, choosing the right materials for interior surfaces and finishes is crucial to improving Indoor Air Quality.
From the standpoint of indoor air quality, the designer should aim for materials that:

- Require the use of the least toxic, low-VOC, water-based adhesives, and coatings constituents.
- Emit little or no odor.
- Are not susceptible to moisture damage that can encourage mold growth. (EPA, n.d.)

Porosity.

The pore space of a substance is expressed by its porosity in interior materials. Because their molecular structure allows for enhanced absorption and airflow, porous surfaces have more holes and allow liquids to flow through them. Just a few examples are drywall, carpeting, wallpaper, acoustic ceilings, tiles, bricks, and other porous surfaces. Surfaces that are smooth and sealed are considered non-porous. Because of their denser surfaces, they do not absorb liquid or air. A few examples include ceramic tiles, glass, and metal panels.
Porous materials have been found to be adverse for coronavirus survival in recent investigations. COVID-19 is transmitted through respiratory droplets. Droplets that fall on porous surfaces evaporate more quickly than those that fall on non-porous surfaces. COVID-19 viral propagation can be slowed by surfaces that enhance evaporation.

Acoustics.

The importance of acoustics is one of the most important lessons learned during the pandemic. With many of the users working or attending virtual classes at home, often in the same rooms as other family members, the lack of acoustic privacy has become a critical concern. Acoustics are also crucial to long-term health and wellness, and users are becoming more aware of this due to the pandemic.

The interior acoustical design varies from rooms where voice intelligibility is required to spaces where quiet is essential, to spaces where music enhancements are required, to spaces for private communications, and to spaces for public announcements. To generate a suitable acoustical environment, each of these categories will require a unique combination of materiality schemes that balance the physical attributes and their amounts. Acoustical materials include a variety of foams, fabrics, metals, etc.

Anti-Microbial Resistance (AMR).

In a relatively short time, the COVID-19 epidemic has altered our way of life. It is not only about the temporary stay-at-home orders or social distance. The long-term result is likely to be a collective fear of germs, leading to increased interest in antimicrobial building materials and decor, as well as cleaner spaces. (EPA, n.d.)
Antimicrobial compounds by definition and design, are substances that are toxic to bacteria, viruses, fungus, or protozoa — together known as microbes. Antimicrobial properties can be found in a variety of products and cleansers. Solid surfaces, copper & silver metals, Anti-bacterial coatings, and infused products are just a few examples of interior products that are naturally antimicrobial.
Designers should keep the following in mind when selecting anti-microbial interior products for the post-COVID-19 era:

- It takes time for antimicrobial products to become effective.
- Rather of destroying germs, most anti-bacterial coatings limit their growth.
- Antimicrobial products have a variety of negative effects on the environment and human health.

Maintenance.

The most desirable materials are those that are easy to maintain and handle. Maintenance can assist maintain the structure looking new for a longer period of time. Higher-quality building materials normally require less maintenance than lower-quality materials. To ensure effective design, one must research the building's life and quality.

III. DISCUSSION& CONCLUSION

3.1 Detailed Analysis of Materials

The main portion of an interior is taken up by floors and walls. As a result, sustainable flooring and wall materials play an important role in interior design. The following table compares various sustainable flooring and wall finishes based on important interior factors.

MATERIALS	INDOOR AIR QUALITY	POROSITY	ACOUSTICS	ANTI-MICROBIAL RESISTANCE	MAINTENANCE & LIFE CYCLE
1. Bamboo	Bamboo has a low VOC level, which means it meets even the strictest indoor air quality standards.	Bamboo has a porous structure, with a porosity valuebetween 0.3-0.7. Its porous structure includes a large amount of space filled only with air making it comfortable for walking & provides warmth.	The bamboo fiber material possesses acoustic properties equivalent to those of wool. Sound absorption characteristic of bamboo fiber depends on properties such as diameter of fiber, thickness & density of materials.	Bamboo is antibacterial and antifungal by nature. After manufacturing processes for improved resistance materials are coated with reduced graphene oxide and nanocrystal Zinc oxide for better mould resistance and antibacterial activity.	Easy to maintain. Average lifespan of bamboo material is 20-25 years**.**
2. Cork	Cork is not free of VOCs, it does contribute to the total VOC level. (Acetic acid, 2-ethyl-1-hexanol, 2-furfuraldehyde, Formaldehyde, Phenol.) However, their numbers are insignificant.	Cork is an even better thermal insulator than bamboo with a porosity value between 0.8 - 1. Its structure includes a high degree of porosity with each tiny air pocket surrounded by impermeable cell walls making it more comfortable than bamboo.	Cork is a great soundproofing material because of its honeycomb-like cell structure and the airspaces trapped inside it. There are around 40 million cells per cubic centimeter. 10dB of sound can be absorbed by a thin layer of cork (3/32").	Cork is antimicrobial, which means it inhibits mold and mildew growth. Most dusts and other pollutants will not stick to it because it is antistatic.	Easy to maintain. Average lifespan of bamboo material is 25 years**.**
3. LVT	Dioxins, phthalates, and ethylene chloride are all produced in large numbers during the manufacture of LVT. There are safe LVT brands with Floor-score Certification. A high-quality brand that provides indoor air quality certification, has an indoor air quality rating of 8 out of 10.	Vinyl is a non-porous structure. Therefore, making it a floor resistant to high moisture and spills.	LVT flooring has natural sound absorbing quality. Vinyl material has excellent performance in acoustic noise reduction (16-19dB)	LVT is not naturally anti-microbial. An ionic silver additive is added to the material that provides a hygienic surface where bacteria cannot multiply or survive. This active ingredient has been proven to reduce bacteria present by > 99.99% over 24 hours.	Low maintenance. Average lifespan of LVT is 20 years.

4. Ceramics	Although ceramics do not produce volatile organic compounds (VOCs), the adhesives used to adhere it to the floor can be a source of indoor pollution.Air Quality of ceramics equivalent to bamboo, so it gains a score of 9 out of 10.	Ceramic has a porous structure with pore diameter of 2.2. The effect of porosity & pore size of ceramics makes it thermal shock resistance and increases water absorbency.	Ceramic tile is a relatively hard surface floor covering, making soundproofing challenging. Even with a high-quality acoustical membrane, outcomes on par with conventional floor coverings are unlikely.	Ceramic tiles have no antibacterial properties, allowing germs to thrive on their surfaces.Titanium dioxide enriched with silver layer is coated to provide Anti-microbial property to ceramic surface.	Easy to maintain as they are staining resistant. Average lifespan 75 years.
5. Recycled Rubber	Natural rubber flooring that is of high quality does not include PVC, phthalates, or chlorine, which contributes to better indoor air quality. There are various brands of recycled rubber flooring with Floor-score Certification.	Recycled rubber has porous structure which increases the frictional force of the floor.	The rubber structure has excellent acoustic and mechanical properties. It aids in the reduction of structural vibration and noise transmission within the interior.	Rubber is not naturally antibacterial. Rubber material is treated with silver nanoparticles which makes it antibacterial resistant. There are various brands providing antimicrobial recycled rubber flooring.	They are easy to maintain and have life span of 15 years or longer.
6. Polished Concrete	Polished concrete also emits very few (VOCs). None is emitted by the concrete, though some are emitted by the hardening agents and the various stains used to color it.	Concrete in its basic nature is porous making it highly permeable to water. However polished concrete by densifying and sealing transforms a porous concrete into a tightened floor that is dense enough to repel water & contaminants.	Concrete surface is solid, so it does not absorb sound. To avoid the reflection of sound acoustic membranes are bonded to provide sound proofing.	Concrete in its basic nature is porous that traps contaminants. Polished concrete is coated with a protective coating which includes silver or isothiazoline based compounds for anti-microbial resistance.	Easy to maintain. Average lifespan is 100 years.
7. Clay Plaster	Clay plaster improves IAQ with its breathability quality. Clay, more than any other building material, has the ability to quickly absorb and desorb internal dampness. Clay plasters have been proven in experiments to be capable of controlling relative indoor humidity levels between 40% and 70%.	Clay plaster has a porous structure that helps to improve relative indoor humidity while also controlling dust mites and other creatures that are harmful to people's health.	Acoustics are absorbed and softened by clay plasters. It has an NRC of 0.1 and sound absorption coefficient of 0.09N.	Clay plasters are naturally antibacterial. Nanoscale (200 nm), illite-smectite, and reduced iron phases are seen in clays.	Clay plaster has a 60-year lifespan and requires little maintenance.

8. Glass Mosaic Tiles	Glass mosaic tile contains zero VOCs or other harmful substances, even in the case of fire. Usage of adhesives and grouts produce very low quantity of contaminants.	Glass mosaic tiles are non-porous making it easy to maintain.	Glass is an excellent material for soundproofing as they are non-porous.Acoustic property of glass differs based on their thickness.	Glass surface is naturally anti-microbial due to the presence of trace amounts of silver ions leading to the elimination of microorganisms and stains.	Easy to maintain. Average lifespan of 10-15 years.
9. Copper	Copper is a proper choice of material for improving IAQ due to its natural resistance to microorganisms. The International Copper Association (ICA) has recommended the use of copper ducting in ventilation and central AC networks promotes IAQ.	Copper has a porous structure.	Copper combines with zinc to make brass which has better acoustic properties than copper alone.	Because of the presence of ions, copper, and its alloys, such as brass, bronze, and copper-nickel, are naturally antibacterial. Copper-nickel alloys, which offer good strength, durability, and corrosion resistance, are a preferred choice for antimicrobial touch surface applications.	Should be properly maintained. Average lifespan 70-80 years.
10. Wool Felt Coverings	Wool felt almost act like a natural HVAC filter, purifying indoor air by absorbing noxious gases and regulating free moisture in the air.	Wool felt has a porous structure and built-in capillary channels, which is exceptionally suited to absorb and prevent undesirable particles, like dust or carbon, etc.	Wool felt coverings have excellent acoustic properties. Felt coverings have a NRC ranging from 0.2-1.2.	Wool felt is naturally anti-microbial.	Easy to maintain. Average lifespan is 10-15 years.
11. Paints	Interior wall paints are recognized as a source of VOCs in the indoor environment. Based on the types of paints, contaminants differ. There are latest brands of paints with claims of zero VOC's. According to USEPA, Zero or No VOC's paints still has TVOC emissions above zero when tested in an emissions chamber	Paints are micro porous that allow any moisture trapped in the wall surface to evaporate. Emulsion paints are non-porous due to their cross-linking polymer.	Paint finishes do not have acoustic properties. Acoustic paints are made by formulating with ceramic microspheres.	Anti–microbial paint is manufactured by silver-bac technology or other additives.	Maintenance of paint finish depends on the type of paints. Life span varies from 2-15 years (varies according to type of paint).

3.2 Findings of the Analysis

In this analysis, the materials are compared using the essential parameters in the post COVID. Since the majority of sustainable materials compared emit low or no VOCs, they all provide comfortable indoor environment. Function of the space is a crucial factor for the porosity of the material. Non-porous surfaces, such as ceramic tiles, glass mosaic tiles, vinyl surfaces, metal alloys,and other non-porous surfaces, are denser and do not

absorb liquid or air. Even though non- porous do not attract dust or microbes, COVID-19 viruses sustain more on non-porous surface compared to porous surfaces. COVID-19 is transmitted through respiratory droplets. These droplets evaporate easily from porous surfaces than non-porous surfaces.

For most materials, antimicrobial resistance is an unavoidable factor. Microbe resistance is naturally inherent in many sustainable materials. Following COVID, all brands are now creating microbial-resistant interior materials. Most sustainable materials have a lengthy life cycle and are simple to maintain.

The proper use of natural resources and passive energy, as well as the selection of appropriate materials, will help us preserve an aesthetic and sumptuous experience while also assisting us in living healthier lives in healthier homes.

The limitation of the research paper starts with being unable to collect physical samples due to COVID 19.Research papers and articles regarding the adaptation of materials and built environment in the post COVID scenario is still limited. Since the pandemic began there have been new innovative antibacterial materials in the market but there is lack of awareness about them. Hence information and knowledge regarding the experience with materials from users is limited.

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