REVIEW ARTICLE

Journal of Ecophysiology and Occupational Health, *Vol 23(4), DOI: 10.18311/jeoh/2023/34743, 249-257, December 2023*
ISSN (Online) : 0972-4397
ISSN (Online) : 0974-0805

Microbiological Load on the Various Surfaces

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Abstract

Microorganisms are ubiquitous, including within habitats, and they have a negative impact on human health, sanitation, and living situations. Surface microbial load is affected by various factors such as location, usage, cleaning, and environment. Kitchen countertops, toilet fittings, doorknobs, electrical appliances, and fabrics can harbor bacteria, viruses, fungi, and archaea. These pathogens may originate from persons, air or external sources. It is known that high microbial loads on surfaces cause health hazards. Pathogenic bacteria can live for extended durations on surfaces, causing infections by contact or aerosolization. Surface microbial load can be decreased through cleaning and disinfection processes. Reducing microbiological contamination requires the use of appropriate cleaning products, and procedures. In antimicrobial coatings, silver ions and other disinfectants can inhibit surface bacterium adhesion and growth. To mitigate health risks, it is necessary to comprehend microbial colonization and survival on various surfaces. This article examines common surface bacteria, microbial load factors, transmission pathways, and their impact on human health.

Keywords: Contamination, Currency Notes, Human Health, Microbial Load, Pathogenic Bacteria

1. Introduction

Microorganisms play a crucial role in numerous ecosystems. Microbes affect a variety of indoor and outdoor surfaces. Microbes flourish on surfaces such as phone screens and public transportation handles, which can have negative effects on health, hygiene, and the environment. Microbes on surfaces are dynamic and intricate, influenced by human interaction, environmental conditions, cleaning techniques, and surface characteristics[1]. Understanding the microbiological load of surfaces is essential because it influences human exposure to pathogenic germs and their effects. Surfaces can harbor microorganisms such as bacteria, viruses, fungi, and archaea[2]. These microorganisms may be transmitted through to these surfaces either by an infected person, airborne pollution, or direct contact. The ability of microorganisms to adhere, persist, and potentially grow on surfaces raises concerns about direct contact, aerosolization, and particle transfer to hands and mucous membranes.

The presence of harmful microorganisms on surfaces can damage public health. Respiratory viruses, food-borne bacteria, and allergy fungi are examples of surface-transmitting microorganisms. Biofilms can make bacteria more resistant to washing and disinfection, making surface sanitation more difficult[2]. To lower surface microbial burden, cleaning, disinfectants, and

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Article Received on: 14.08.2023 Accepted on: 11.10.2023 Revised on: 11.10.2023

material science developments are required. Successful public health and hygiene programs rely on the types of microorganisms on various surfaces, their causes of proliferation, and cleaning processes.

The present review investigates the microbiological load on various surfaces, showing the types of bacteria detected their properties, health impacts. Understanding the complicated relationship between germs and surfaces can make daily life safer. Some microorganisms are beneficial, while others are harmful. Every day, a large number of people use the same currency. These microorganisms can cause skin, intestinal, and respiratory problems, among others. Without proper hygiene, many pathogens may enter the body via hand-to-mouth contact[3,4]. They are capable of causing serious digestive, respiratory, and skin problems. The global currency transactions may spread bacterial and fungal illnesses, particularly among susceptible individuals. Dirty surfaces, handling, and storage can taint currency. Before calculating money, saliva on the hands can spread bacteria. In developing nations such as India, where bacterial illnesses are on the rise, these transmission routes have a negative impact on public health. Many governments separate banknotes from illnesses causing microorganisms such as bacteria and fungi. If these bacteria and fungi are prevalent, a number of diseases may develop[3,4].

1.1 Factors Responsible for Contamination of Currency

A combination of factors influences the contamination of currency notes. The unique characteristics of currency notes, their widespread circulation, and the diverse environments they encounter, all contribute to their potential for harboring various contaminants[5]. Some of the key factors responsible for the contamination of currency notes include human contact and exposure to environment[6].

- **Human Contact:** Currency notes are exchanged between many people throughout their lives. The constant handling of notes by people from various backgrounds and with varying levels of personal hygiene raises the possibility of microorganisms being transferred from the hands to the surface of the notes[7].
- **Environmental Exposure:** Currency notes are frequently exposed to a variety of environments, both indoors and out. They may come into contact with surfaces in homes, businesses, public transportation, and outdoor settings, where microorganisms from various sources may be picked up[8].
- **Moisture and Humidity**: Moisture-rich environments are ideal for microorganisms. Currency notes can be exposed to humidity, spills, or damp conditions, creating an ideal environment for the growth of microorganisms such as bacteria and fungi.
- **Airborne Contaminants:** Dust, pollen, and microorganisms can settle on currency notes, especially if they are stored or circulated in areas with poor air quality or high levels of particulate matter.
- **Cross-Contamination:** Currency notes can come into contact with contaminated items such as wallets, purses, pockets, and the surfaces on which they are placed. This cross-contamination can introduce a variety of microorganisms onto the surfaces of the notes[9].
- **Frequency of Circulation:** Highly circulated denominations change hands more frequently, increasing their exposure to different people and environments and, as a result, increasing the risk of contamination[10].
- **Poor Personal Hygiene:** Individuals may handle currency notes without adequately washing their hands after using restrooms, handling food, or engaging in activities that expose them to potential sources of contamination[11].
- **Lack of Regular Cleaning:** Currency notes are not routinely cleaned, unlike other frequently handled items. This lack of cleaning provides a conducive environment for accumulating microorganisms and contaminants[12].
- **Presence of Residues:** Traces of substances such as oils, food particles, and bodily fluids from handling can provide nutrients and a substrate for microorganisms to grow on currency notes[13].
- **Microbial Survival:** Some microorganisms can survive on surfaces for extended periods. Pathogenic bacteria and viruses can potentially remain viable on currency notes, increasing the risk of transmission if individuals come into contact with contaminated notes and subsequently touch their faces or food[14].
- **Material Composition:** The material used in currency notes, such as cotton or polymer, can influence how well microorganisms adhere to and survive on their surfaces. Porous materials might provide crevices for

microorganisms to hide, while smoother surfaces might be less conducive to their attachment[15].

Given these factors, it is essential to consider the potential contamination of currency notes and promote good hygiene practices among individuals who handle them regularly. While the risk of disease transmission through currency notes is relatively low compared to direct person-to-person contact, maintaining proper hygiene, washing hands frequently, and handling notes with care can help mitigate the potential risks of contaminated currency.

2. Common Types of Microbes on the Surfaces

Cash meets daily needs, making it essential to life. Many exchanges use cash, with lower-group notes most commonly traded. People with different health and hygiene standards handle and store cash and coins. Paper money provides a large microbe-friendly surface. Some contagious species are likely plant and human microbes. Additionally, funding pathogenic microorganisms addresses a neglected disease supply. To protect human health, cash notes and coins should be handled carefully. The public should know currency notes are infectious and harmful. Public education campaigns on legal cash dealing should be coordinated. People worldwide deal with cash, whether in coins or paper notes[2]. Cash is used for trade, debt repayment, and financial installments. In the current writing audit, microbial defilement of paper money is explained by reaching different conditions and people around the world. This survey found parasites like *Aspergillus flavus, A. niger,* and *Penicillium spp., Trichoderma species* and *Alternaria tenuis, Fusarium, Trichoderma viride, A. paraziticus, Sporotrichum,* and other microbial defilements[3].

Banknotes made of cotton paper and polymer substrates from multiple regions were analyzed. Swabbing banknote surfaces and growing samples on selective growth media assessed microbial load[4]. The current study also examined the survival rates of bacteria, fungi, and viruses on banknote surfaces in controlled conditions. Bacterial and fungal contamination was found on all banknotes. The microbial composition varied by banknote material, local environment, and handling. Microbes were less present on polymer banknotes than cotton paper ones, possibly due to their less porous surfaces[16].

Some microorganisms survived on banknote surfaces for long periods, according to survival rate experiments. Humidity and temperature affected bacterial and fungal survival.

Currency notes are widely used and may accumulate microorganisms that harm public health[6]. This study examines microbial contamination on Indian currency notes in circulation *in vitro*, highlighting currency handling risks. A representative sample of currency notes was surveyed across India's denominations and regions. Swabbing and microbial culture assessed microbial contamination. The study identified bacterial and fungal species, assessed their load, and examined currency note microbial factors. Indian currency notes were contaminated with bacteria and fungi. Microorganisms like *Staphylococcus aureus, Escherichia coli*, and *Aspergillus* species were found. Higher denominations and urban notes had higher microbial loads, possibly due to circulation and handling.

The study also examined how environmental conditions, currency storage, and handling habits affect microbial contamination. Humidity levels correlated with microbial presence, indicating that environmental conditions promote currency note microbial growth. Fomites like these notes can spread pathogens. This study emphasizes the importance of promoting proper hygiene practices, such as hand washing after currency handling, to reduce microbial contamination risks.

Currency and coins are frequently touched by humans and exposed to various microorganisms. A study regarding the presence of microbial load on paper/polymer currency notes and coins was done in order to address the health-associated risks with currency circulation[17]. Currency notes and coins of various denominations from various locations were collected. Microbial load assessment involved swabbing surfaces, growing samples on selective media, and identifying bacteria and fungi. They have found that microbes were abundant on paper and polymer currency notes as compared to coins. Polymer currency had lower microbial loads than paper currency, possibly due to its less porous surface and lower adhesion. Different microbial loads in coins and notes emphasize the importance of material and usage patterns when assessing microbial contamination risks[17]. Important public health implications of currency and coin microbial load. Currency is unlikely to transmit diseases directly, but microorganisms suggest indirect

transmission through hands and surfaces. Currency handling risks can be reduced by good hand hygiene[17].

The microbial load on currency surfaces is examined using swabbing and microbial culture in this comprehensive survey across regions and denominations. Bacteria and fungi are identified and contamination is quantified based on material composition, usage frequency, and local environmental conditions[7]. They found that currency notes and coins have a high microbial load of pathogenic bacteria like *Staphylococcus aureus, Escherichia coli,* and environmental fungi. Microorganism diversity varied by currency type, highlighting the role of material composition in microbial contamination patterns. Microbial contamination of currency surfaces may cause indirect transmission through hand-to-mouth contact. This study also emphasizes the importance of microorganism persistence on currency surfaces[18].

Paper money and coins, used in daily transactions, can spread pathogenic bacteria, viruses, and fungi[19]. Understanding currency circulation risks can help prevent transmissible diseases from spreading through this often-overlooked route[20,21]. Exploring the persistence of microorganisms on currency surfaces has shown that some bacteria and viruses can survive for long periods. This persistence, along with frequent currency note exchange and hand-to-face contact, highlights paper currencies as potential disease carriers. People could spread microorganisms from contaminated currency to their hands, mouths, eyes, and noses, threatening public health. This transfer could spread infections and diseases, especially in high-traffic public areas[20,21].

3. Method of Detection of Microbes from the Surfaces

The study of the microbiological load on various surfaces involves a range of materials and methods to effectively characterize, quantify, and analyze microorganisms on different surfaces. Researchers employ diverse techniques to investigate the types of microorganisms, their abundance, and the factors influencing their presence. In this section some common materials and methods for estimating the microbial load on the surface of various objects are discussed below section as per the literature survey[22-26]:

- **Swabs and Sampling Kits:** Sterile swabs and sampling kits are essential for collecting microbial surface samples. Swabs are used to wipe surfaces, transferring adhered microorganisms onto the swab tip for further analysis.
- **Culture Media:** Different types of culture media, including agar plates and broths, are used to encourage the growth of specific microorganisms. These media support the growth of bacteria, fungi, and other microorganisms, allowing researchers to isolate and identify them.
- **Transport Media:** Specialized transport media are used to maintain the viability of microorganisms during transport from the sampling site to the laboratory. These media provide a stable environment for microorganisms to survive until they can be processed.
- **Microscopy Slides and Stains:** Microscopy slides observe microorganisms directly under a microscope. Stains, such as Gram stain for bacterial classification or fluorescent dyes for specific cell components, can enhance visualization.
- **DNA Extraction Kits:** DNA extraction kits provide the tools and reagents needed to extract genetic material from microorganisms. This extracted DNA can be used for various molecular analyses, such as Polymerase Chain Reaction (PCR) and DNA sequencing.
- **Antibiotic Sensitivity Discs:** These discs are impregnated with specific antibiotics and are used to determine the antibiotic susceptibility of isolated bacteria. The diameter of the zone of inhibition around the disc indicates bacterial susceptibility to the antibiotic.

4. Persistence of Pathogens on Surfaces

Money is a common but often-ignored reservoir for enteric disease[27]. Paper currency can become the place where various pathogenic microorganisms can grow. As per the study it had been found that these microorganisms had developed intricate, distinct physiologic resting stages that enable them to survive or hibernate when water activity is low. Studies on ordinary paper showed that the survival time of microorganisms varies depending on the room's environment, but they remained cultivable after seven days and were stable on paper for up to 72 hours[28,29]. Some gram-negative bacteria can survive on coins for as long as eleven days, and the influenza virus can survive on currency notes for about three to seventeen days[30,31].

5. Bacterial Pathogens

Bacterial pathogens are a significant subset of microorganisms contributing to the microbiological load on various surfaces. These pathogens can potentially cause diseases in humans, and their presence on surfaces can lead to the transmission of infections through direct contact or indirect routes. Understanding the characteristics of bacterial pathogens on surfaces is crucial for maintaining public health and preventing the spread of infectious diseases. Here are some key points concerning bacterial pathogens in the context of the microbiological load on surfaces[32,33].

- **Pathogenic Diversity:** Bacterial pathogens encompass a wide range of species that can cause diverse illnesses, from mild infections to severe and life-threatening diseases. Examples of bacterial pathogens include *Salmonella, Escherichia coli*, *Staphylococcus aureus*, *Streptococcus pyogenes*, and *Listeria monocytogenes*.
- **Transmission Routes:** Bacterial pathogens can be transferred to surfaces through various means, including contaminated hands, respiratory droplets, bodily fluids, and cross-contamination from contaminated foods. Once on surfaces, these bacteria can persist and potentially infect individuals who come into contact with the contaminated surfaces.
- **Food-Borne Illness:** Many bacterial pathogens are associated with food-borne illnesses. These bacteria can contaminate surfaces in food preparation areas, leading to cross-contamination when the bacteria are transferred from surfaces to food items.
- **Healthcare-Associated Infections (HAIs):** Bacterial pathogens can survive on surfaces in healthcare settings and contribute to HAIs. Contaminated surfaces, medical equipment, and hands can all serve as transmission sources for patients and healthcare workers.
- **Antimicrobial Resistance:** Some bacterial pathogens have resisted multiple antibiotics, making infections difficult to treat. This has significant implications for healthcare, as infections caused by antibiotic-resistant bacteria are more challenging to manage.
- Biofilms: Bacterial pathogens can form biofilms on surfaces, particularly in moist areas. Biofilms protect bacteria, making them more resistant to disinfection and contributing to their persistence on surfaces.
- **High-Touch Surfaces:** Bacterial pathogens are often found on high-touch surfaces such as doorknobs, handles, elevator buttons, and shared electronic devices. These surfaces are more likely to be contaminated due to frequent human contact.
- **Preventive Measures:** Preventing the spread of bacterial pathogens from surfaces involves implementing proper hygiene practices, regular cleaning, and targeted disinfection. Hand washing is a critical preventive measure, especially after touching surfaces in public spaces.
- **Surface-Specific Considerations:** Different surfaces can harbor bacterial pathogens differently. Porous surfaces might provide more hiding places for bacteria, while smoother surfaces might allow easier cleaning.
- **Public Awareness:** Raising public awareness about the potential risks of bacterial pathogens on surfaces and educating individuals about proper hand hygiene and surface cleaning practices is essential in reducing transmission.

Figure 1. Contamination of bacteria.

6. Other Agents

In addition to bacteria, viruses, and fungi, several other agents can contribute to the microbiological load on various surfaces. These agents, often found in indoor and outdoor environments, can have implications for human health, hygiene, and the overall cleanliness of surfaces. Some of these agents are discussed below on the basis of the literature reviewed[34,35].

- **Archaea:** Archaea are single-celled microorganisms distinct from bacteria and have unique metabolic pathways. While they are less commonly studied

in surface microbiology, they can still be found on surfaces and contribute to the microbial community.

- **Algae:** Algae are photosynthetic microorganisms that can be present on surfaces exposed to light and moisture. They are commonly found outdoors on surfaces such as walls, sidewalks, and buildings, creating unsightly discoloration.
- **Protozoa:** Protozoa are single-celled eukaryotic microorganisms found in water sources and on surfaces with moisture. While they are not as prevalent on surfaces as bacteria or fungi, they can still be present in specific environments.
- **Dust Mites:** Dust mites are microscopic arthropods that feed on dead skin cells and are commonly found in household dust. They can accumulate on bedding, upholstered furniture, and carpets.
- **Allergens:** Allergens are substances that trigger allergic reactions in sensitive individuals. These can include proteins from pollen, dust mites, mold spores, and pet dander, which can settle on various surfaces.
- **Mold and Mildew:** Mold and mildew are fungi that thrive in damp environments. They can grow on surfaces such as walls, ceilings, and bathroom fixtures; their presence can indicate poor ventilation or moisture issues.
- **Insects and Insect Parts:** Insects and their body parts can be on surfaces, especially in outdoor environments or areas with poor pest control, which includes insect fragments, excrement, or even whole insects.
- **Chemical Residues:** Chemical residues from cleaning agents, disinfectants, and other substances can accumulate on surfaces and contribute to the overall load. While not biological, these residues can interact with microorganisms and impact their survival.
- **Volatile Organic Compounds (VOCs):** VOCs are organic chemicals that can off-gas from various materials and products. They can contribute to indoor air quality issues and interact with surface microorganisms.
- **Airborne Particles:** Airborne particles such as dust, pollen, spores, and other microorganisms can settle on surfaces, adding to the overall microbiological load.
- **Human Shed Cells:** Humans shed skin cells, hair, and other biological material constantly. While not microorganisms themselves, these shed cells can serve as a substrate for microbial growth on surfaces.

Understanding the presence and impact of these various agents on surfaces is crucial for maintaining clean and healthy indoor and outdoor environments. Proper cleaning, disinfection, and ventilation practices can help reduce the accumulation of these agents and promote overall hygiene and well-being.

7. Currency and Food-Borne Illness

Currency notes themselves are not a primary source of contamination but they can facilitate the transfer of microorganisms and contribute to the spread of pathogens associated with food-borne diseases. Several factors that contribute to the connection between currency and food-borne illnesses are discussed below[17,21,22,36,37].

- **Handling and Cross-Contamination:** Currency notes are frequently handled by a diverse range of individuals, each with varying hygiene practices. People may touch currency after handling food, visiting restrooms, or coming into contact with contaminated surfaces. As a result, currency notes can become contaminated with microorganisms, including pathogens that cause food-borne illnesses.
- **Microbial Survival:** Some microorganisms, including bacteria and viruses, can survive on surfaces like currency notes for extended periods, especially if the conditions are conducive to their viability. This increases the potential for these pathogens to be transferred to hands and then to food, leading to food-borne illness if the contaminated hands come into contact with the mouth or food.
- **Transmission Routes:** Contaminated currency can serve as a potential vehicle for pathogens to be transmitted from person to person. For instance, if a person who has handled contaminated currency prepares or serves food, the microorganisms present in their hands can be transferred to the food, leading to the potential for food-borne illness in consumers.
- **Poor Hand Hygiene:** Inadequate hand hygiene practices, such as not washing hands after using the restroom or before handling food, can contribute to the transfer of microorganisms from currency to hands and subsequently to food.

- **High Frequency of Handling:** Currency notes are exchanged frequently, increasing the likelihood of cross-contamination. This is particularly relevant in environments where food is prepared, served, or consumed, such as markets, street food stalls, and restaurants.
- **Vulnerability of Food Handlers:** Individuals involved in the preparation and handling of food may handle currency notes and food interchangeably. This can lead to the transfer of microorganisms from currency to hands to food, putting consumers at risk of food-borne illnesses.

  To mitigate the potential risk of currency-related transmission of food-borne illnesses, several measures can be considered:
- **Regular Hand Washing:** Encouraging proper hand washing practices among food handlers and consumers is essential to prevent the transfer of microorganisms from currency to hands to food.
- **Good Hygiene Practices:** Food handlers should be educated about the importance of hygiene and the need to avoid handling currency while working with food.
- **Use of Gloves:** Food handlers can use disposable gloves to reduce the risk of cross-contamination between currency and food.
- **Antibacterial Treatments:** Research into antimicrobial treatments for currency notes, which could reduce the survival of microorganisms on the surface, could provide an additional layer of protection.
- **Contactless Payments:** The adoption of contactless payment methods, which reduce the need for physical currency exchange, can help minimize the potential for microbial transmission through currency.

While the risk of acquiring food-borne illnesses through currency is generally low compared to direct consumption of contaminated food, promoting hygiene awareness and implementing best practices can contribute to safer food handling and reduce the potential for transmission of pathogens associated with food-borne diseases.

8. Conclusion

This study revealed a complex interaction between microorganisms, human interactions, and environmental conditions. Surface microorganisms impact public health, hygiene, and indoor and outdoor environments. This field is dynamic and multifaceted, as evidenced by the wide range of studied surfaces and microorganisms discovered. This review demonstrates that a holistic approach is required for understanding and managing surface microbiological load. Pathogenic bacteria, viruses, fungi, and other microorganisms are capable of surviving on surfaces and spreading via direct contact, aerosolization, and cross-contamination. Resilient biofilms make cleaning and disinfection harder. Protecting public health requires minimizing the dangers of contaminated surfaces. Regular cleaning, the use of suitable disinfectants, and consideration of antimicrobial developments can reduce microbial contamination. The dissemination of hygienic awareness, including hand washing and surface care, is essential for disease prevention.

The analysis of surface microorganism diversity and abundance has been revolutionized by molecular, genomic, and advanced imaging techniques. These techniques revealed hidden microbial landscapes, which culture-based techniques were unable to do. Additional research will illuminate the unexplored aspects of surface microbiology. This includes studying how microbial communities degrade materials, how surfaces store genes for antimicrobial resistance, and how innovative technologies can create self-sanitizing surfaces. This study informs strategies for disease prevention and highlights the need for cleaner, healthier environments.

9. Acknowledgments

The authors wish to acknowledge the cooperation and assistance received from Dr Rammanohar Lohia Avadh University. The corresponding author, Vinod Kumar Chaudhary, is thankful to Professor Siddhartha Shukla, Department of Environmental Sciences, Dr. Rammanohar Lohia Avadh University, Ayodhya; Professor Neelam Pathak, Department of Biochemistry, Dr. Rammanohar Lohia Avadh University for providing the necessary lab and equipment and other anonymous reviewers for their valuable suggestions to improve this review.

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