

RESEARCH ARTICLE

Environmental Contamination and Antibiotic Resistance of *Staphylococcus aureus* Isolated from Paper Currency in Dhaka, Bangladesh

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ABSTRACT

Paper currency is one of the most commonly exchanged items in daily life and can serve as a potential vehicle for the transmission of pathogenic microorganisms. This study aimed to assess the environmental contamination and antibiotic resistance profiles of *Staphylococcus aureus* isolated from paper money collected from various sources in Dhaka, Bangladesh. A total of 40 paper currency samples of different denominations (Tk 10, 20, 50, 100, and 1000) were collected from super shops, fish and vegetable markets, public transport, and new banknotes. Samples were swabbed, cultured on Mannitol Salt Agar (MSA), and incubated at 37°C for 24 hours. Isolates were identified through Gram staining, hemolysis pattern, and standard biochemical tests, followed by antibiotic susceptibility testing using the Kirby-Bauer disk diffusion method according to CLSI guidelines.

All samples (100%) were contaminated with *S. aureus*. The highest contamination was observed in lower denomination notes (Tk 10 and Tk 20), particularly from fish and vegetable markets. Antibiotic susceptibility testing revealed high resistance to oxacillin (75%) and cefoxitin (60%), indicating the presence of methicillin-resistant *S. aureus* (MRSA). However, isolates showed complete susceptibility to tetracycline, amikacin, and cotrimoxazole. These findings suggest that paper currency acts as a significant environmental reservoir for antibiotic-resistant bacteria, contributing to community-level pathogen transmission. Enhanced public hygiene awareness, reduced cash handling, and the introduction of polymer-based banknotes are recommended to minimize this public health risk.

Keywords: *Staphylococcus aureus*; MRSA; paper currency contamination; environmental microbiology; antibiotic resistance

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1. Introduction

Paper currency is an essential medium of exchange in daily life, facilitating the trade of goods, services, and amenities worldwide. Due to its frequent handling and circulation among multiple individuals, currency is continually exposed to a variety of environmental surfaces and human contact. The physical characteristics of banknotes, including their fibrous texture and irregular surface, make them particularly susceptible to microbial contamination^[1]. These surfaces can trap and harbor microorganisms, allowing them to survive for extended periods and potentially serve as vectors for transmission. Several studies have highlighted the microbial burden of paper money, indicating that it can carry more bacteria than objects commonly regarded as unhygienic, such as household toilets. For example, a study conducted in 2014 by Mastercard in collaboration with the University of Oxford reported that an average banknote can harbor approximately 26,000 bacterial species, including pathogenic and opportunistic bacteria such as *Staphylococcus aureus*^[2,3].

Staphylococcus aureus, commonly known as staph, is a Gram-positive bacterium that naturally colonizes the skin, nares, and mucous membranes of humans. It is estimated that about one-third of the population carry *S. aureus* asymptomatically, without exhibiting any signs of infection. While generally harmless in healthy individuals, *S. aureus* can become pathogenic when it breaches the skin or mucosal barriers through cuts, abrasions, or wounds^[4]. In such cases, it can cause a wide spectrum of infections ranging from minor skin infections, such as boils and abscesses, to more severe conditions, including pneumonia, bloodstream infections, and endocarditis^[5].

A growing concern in public health is the emergence of methicillin-resistant *Staphylococcus aureus* (MRSA), a strain resistant to beta-lactam antibiotics, including methicillin and other commonly used penicillins^[6]. MRSA infections are notoriously difficult to treat and have been associated with higher morbidity and mortality rates compared to infections caused by methicillin-sensitive *S. aureus*. According to the Centers for Disease Control and Prevention (CDC), approximately 5% of the population are chronic carriers of MRSA, posing a continuous risk of community- and hospital-acquired infections. MRSA colonization and infection are of particular concern in environments with high human contact and limited hygiene control, including marketplaces, public transport, and handling of currency^[7].

Paper currency, due to its frequent exchange among individuals and its contact with diverse environments, has been recognized as a potential vector for MRSA and other pathogenic microorganisms. The transmission of bacteria via banknotes may contribute to the spread of infections within communities, especially in areas with limited sanitation practices. Several studies have confirmed the presence of multidrug-resistant bacteria on circulating banknotes, emphasizing the role of currency in microbial dissemination and the need for public awareness regarding hygienic practices^[8,9].

Understanding the presence and prevalence of MRSA on paper currency is essential for public health surveillance and the development of strategies to mitigate bacterial transmission. By assessing banknotes as potential reservoirs for MRSA, researchers can identify the risks associated with everyday transactions and propose preventive measures, such as promoting hand hygiene, implementing periodic currency disinfection, and raising awareness among the general public. Moreover, studies in specific geographic locations provide insight into local patterns of microbial contamination and help design targeted interventions to reduce the community spread of resistant pathogens^[10].

Despite the well-documented presence of bacteria on currency, limited research has specifically investigated MRSA contamination in banknotes in Bangladesh. Considering the high circulation of paper money in markets, shops, and public transport, it is crucial to evaluate the potential role of banknotes in the transmission of MRSA within communities. This study aims to detect and characterize MRSA present on

paper currency collected from various sources in Bangladesh, providing insights into public health risks and guiding strategies to prevent bacterial transmission via commonly used currency.

2. Methodology

2.1. Study design and sample collection

A cross-sectional study was conducted to investigate the presence of methicillin-resistant *Staphylococcus aureus* (MRSA) on paper currency in Dhaka, Bangladesh. A total of 40 paper currency samples, including denominations of 10, 20, 50, 100, and 1000 Bangladeshi Taka, were collected from various sources: super shops (both old and new notes), fish markets, vegetable shops, public transport, and newly issued banknotes. Each source contributed 8 samples, ensuring representation from commonly circulated currency in both commercial and public settings.

2.2. Isolation of bacteria

Each banknote was aseptically swabbed using a sterile cotton swab pre-moistened with sterile saline. The swabs were streaked onto Mannitol Salt Agar (MSA) plates, which selectively supports the growth of *Staphylococcus* species, and incubated at 37°C for 24 hours. Colonies exhibiting yellow coloration on MSA, indicative of mannitol fermentation, were selected for further analysis.

2.3. Purification and morphological examination

Selected colonies were subcultured on fresh nutrient agar plates to obtain pure cultures. The purity of isolates was confirmed through Gram staining and microscopic examination at 1000X magnification. Gram-positive cocci arranged in clusters were presumptively identified as *Staphylococcus* species.

2.4. Identification of *Staphylococcus aureus*

Presumptive *S. aureus* isolates were characterized using hemolysis patterns on blood agar and a series of biochemical tests, including catalase, coagulase, and oxidase tests, following standard microbiological procedures. The presence of β -hemolysis on blood agar and positive biochemical test results confirmed the identification of *S. aureus*.

2.5. Antibiotic susceptibility testing

Confirmed *S. aureus* isolates were subjected to antibiotic susceptibility testing using the disk diffusion method in accordance with Clinical and Laboratory Standards Institute (CLSI) guidelines. Methicillin resistance was determined using oxacillin or ceftioxin discs, and isolates showing resistance were recorded as methicillin-resistant *Staphylococcus aureus* (MRSA).

2.6. Data analysis

The prevalence of MRSA on paper currency from different sources and denominations was calculated. Results were expressed as percentages, and patterns of contamination were analyzed to identify high-risk sources of currency handling.

3. Result

The bacterial isolates obtained from paper currency were identified based on colony morphology, Gram staining, and biochemical tests. On Mannitol Salt Agar (MSA), the isolates produced yellow colonies with distinct yellow zones, indicating mannitol fermentation. On Blood Agar, the isolates exhibited β -hemolysis, suggesting hemolysin production. Microscopically, the isolates appeared as Gram-positive cocci arranged in clusters. Biochemical tests revealed positive results for catalase and coagulase, and negative for oxidase, confirming the isolates as *Staphylococcus aureus*.

Table 1. Biochemical and Morphological Characterization of *S. aureus* Isolated from Paper Currency

Biochemical/Morphological Test	Result/ Observation
Coagulase	+ve
Catalase	+ve
Oxidase	-ve
MSA Agar	Yellow colonies with yellow zones
Blood Agar	Beta hemolytic
Gram Staining	Gram +ve, clustered cocci

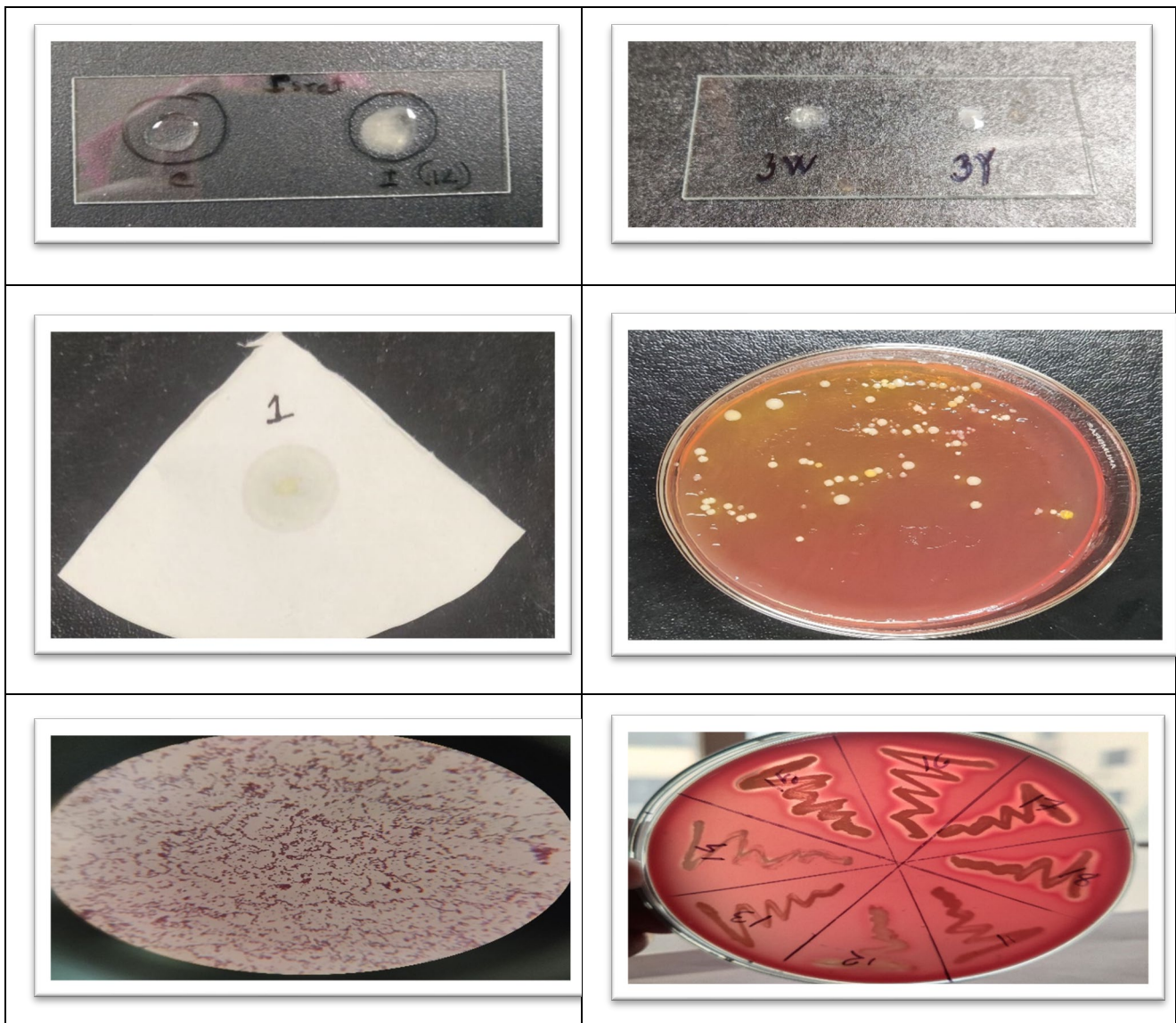


Figure 1. Biochemical tests for *S.aureus* identification

The carbohydrate fermentation assay showed variable acid production patterns across different sugars. The isolates fermented ribose, galactose, mannose, inulin, sucrose, mannitol, lactose, and dextrose, indicating broad carbohydrate utilization ability. No acid production was observed for salicin, xylose, arabinose, or raffinose, highlighting selective metabolic activity.

Table 2. Carbohydrate Fermentation Profiling of *S. aureus* Isolated from Paper Currency

Carbohydrate	Acid production
Ribose	+
Galactose	+
Mannose	+
Inulin	+
Sucrose	+
Salicin	-
Xylose	-
Mannitol	+
Lactose	+
Arabinose	-
Raffinose	-
Dextrose	+

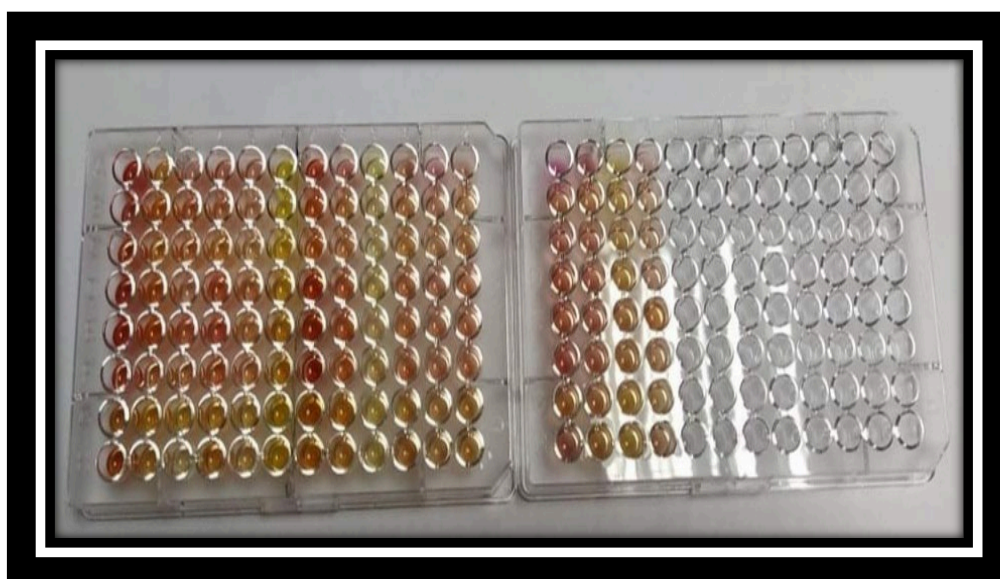


Figure 2. Carbohydrate Fermentation Assay

Antibiotic susceptibility testing was performed according to CLSI (M100) guidelines. The results demonstrated variable resistance patterns among the *S. aureus* isolates. High resistance was observed to β -lactam antibiotics such as oxacillin (75% resistant) and cefoxitin (60% resistant), indicating methicillin resistance. In contrast, all isolates were susceptible to tetracycline, amikacin, and cotrimoxazole. Moderate resistance was recorded for colistin, ceftriaxone, and vancomycin, while ciprofloxacin and azithromycin showed mixed sensitivity patterns.

Table 3. Antibiotic Susceptibility Pattern of *S. aureus* Isolates Collected from Paper Currency (n=40)

SI	Antibiotic	Class	Susceptible number (%)	Intermediate number (%)	Resistant number (%)
1	Oxacillin	β -lactam	6	4	30
2	Tetracycline	Tetracycline	40	0	0
3	Ciprofloxacin	Fluroquinolone	28	8	4
4	Azithromycin	Macrolide	32	0	8
5	Amikacin	Aminoglycoside	40	0	0
6	Cotrimoxazole	Sulfonamide	40	0	0
7	Colistin	Polymixin	4	22	14
8	Ceftriaxone	Cephalosporin	13	21	6
9	Cefoxitin	Cephalosporin	5	11	24
10	Vancomycin	Glycopeptide	13	20	7

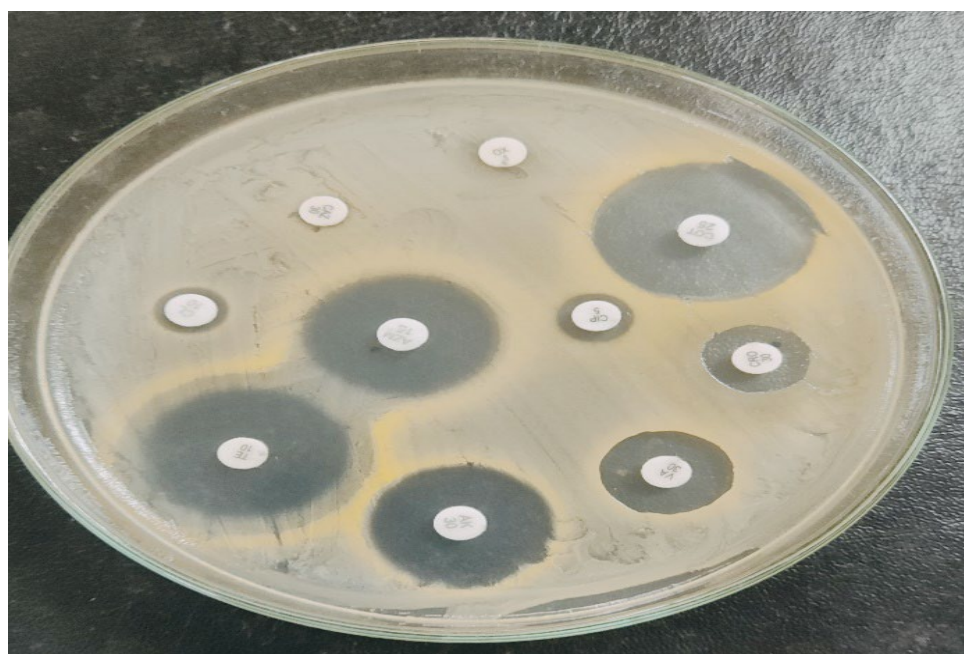


Figure 3. Antibiotic disk diffusion test against *Saureus*

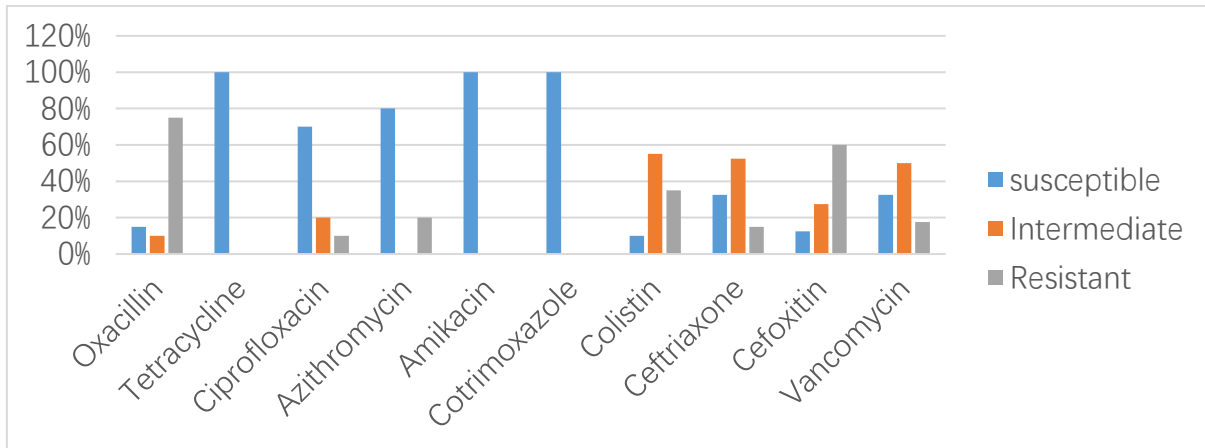


Figure 4. Percentage of susceptibility pattern

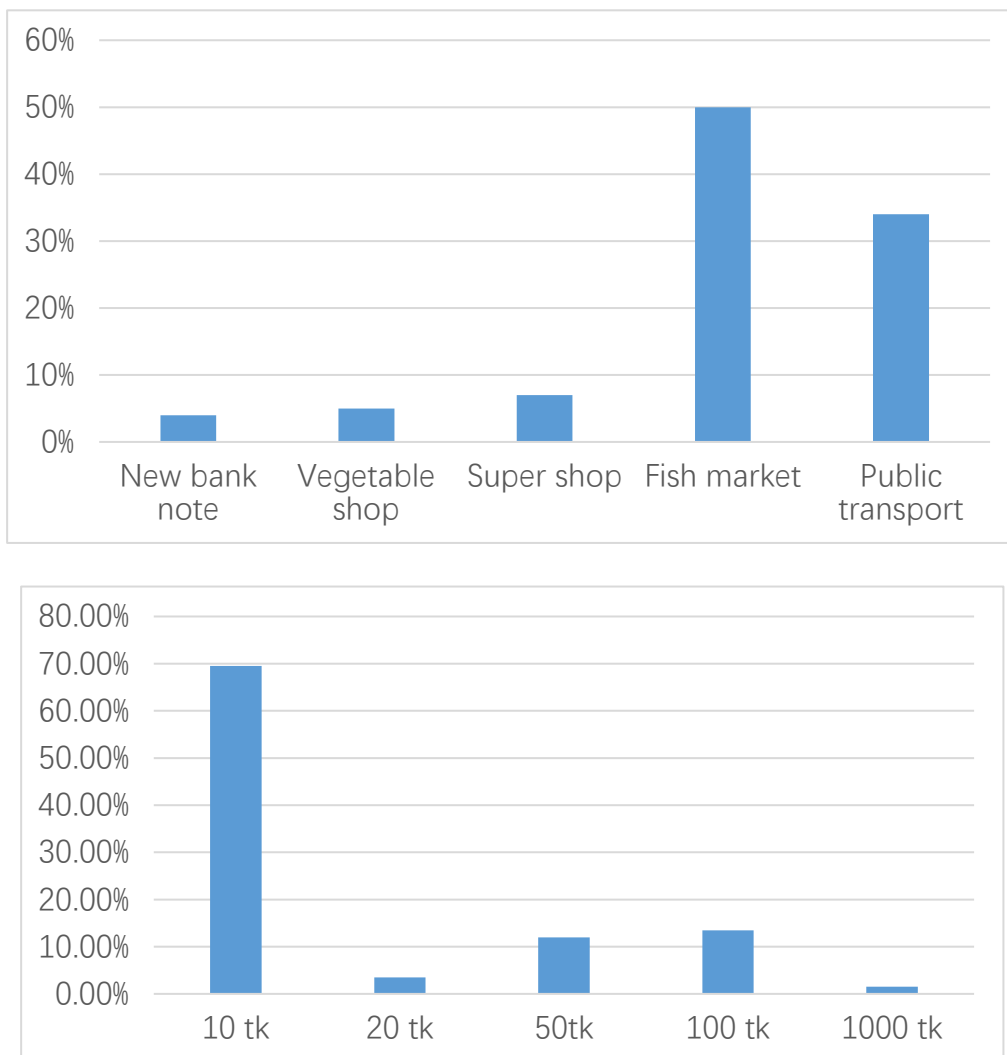


Figure 5: Percentage of *S.aureus* isolate in different sources and denominations

4. Discussion

The present study investigated the occurrence, biochemical characteristics, and antibiotic resistance patterns of *Staphylococcus aureus* isolated from paper currency collected from various sources in Dhaka, Bangladesh. The findings revealed that paper money, a frequently handled medium of exchange, serves as an important reservoir of pathogenic bacteria, including methicillin-resistant *Staphylococcus aureus* (MRSA), posing a potential risk for public health transmission.

In this study, *S. aureus* was recovered from 100% (40/40) of the examined paper currency samples, clearly indicating that pathogenic microbes are circulating widely through money handling. A particularly high number of *S. aureus* isolates were obtained from fish market samples, suggesting unhygienic handling, improper storage, and cross-contamination of products in these environments. The denomination-wise contamination pattern revealed that Tk 10 notes were the most contaminated, while Tk 1000 notes had the least bacterial load. This trend can be attributed to the higher circulation frequency and extensive human contact associated with lower denomination notes^[11].

Phenotypic and biochemical characterization confirmed the isolates as *S. aureus* based on Gram staining, selective growth on Mannitol Salt Agar (MSA), β -hemolysis on Blood Agar, and positive catalase and coagulase tests. These findings are consistent with previous studies, confirming that *S. aureus* thrives in nutrient-rich and high-salt environments and forms golden-yellow colonies with distinct hemolytic activity. The carbohydrate fermentation profile further demonstrated metabolic versatility, showing positive reactions for ribose, galactose, mannose, sucrose, mannitol, lactose, and dextrose—traits typical of *S. aureus* that support its survival on nutrient-poor surfaces such as banknotes^[12].

The antibiotic susceptibility pattern revealed that oxacillin was largely ineffective, with 75% of isolates exhibiting resistance, thereby confirming the presence of MRSA. Additionally, 60% of isolates showed moderate resistance to cefoxitin. However, high susceptibility was observed to tetracycline (100%), amikacin (100%), and cotrimoxazole (100%), suggesting that these antibiotics may remain effective treatment options for *S. aureus* infections. Moderate resistance to vancomycin and ceftriaxone was also observed, indicating emerging resistance trends that require continuous monitoring^[13].

The presence of MRSA on frequently handled banknotes is alarming and signifies a potential route for community-acquired MRSA transmission. Handling contaminated currency without proper hygiene practices can facilitate the spread of antibiotic-resistant pathogens. Similar findings from studies conducted in India, Nigeria, and Egypt highlight that currency contamination is a common issue in developing countries where cash transactions dominate daily commerce^[14,15].

These results underscore the urgent need for public awareness regarding proper currency hygiene and handwashing practices, particularly for individuals working in food markets, transport sectors, and other high-contact professions. Encouraging digital payment methods and introducing polymer-based or antimicrobial-coated banknotes, as implemented in some developed countries, could further minimize microbial transmission through physical money exchange.

5. Conclusion

The detection of a high prevalence of *Staphylococcus aureus* and methicillin-resistant *S. aureus* (MRSA) from paper currency indicates that banknotes play a significant role in the transmission of potentially harmful microorganisms. The findings highlight the urgent need for improved public hygiene practices and awareness regarding money handling. Regular handwashing, reduced cash handling, and the introduction of

safer, polymer-based banknotes could help mitigate the risk of bacterial contamination and the spread of antibiotic-resistant pathogens in the community.

Conflict of interest

The authors declare no conflict of interest

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